

Quantum-Geometry Dynamics

An Axiomatic Approach to Physics

by

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Table of Contents

Hilbert's 6th problem.....	1
Two Ways to do Science	3
The Axiomatic Approach.....	4
About the Source of Incompatibilities between Theories	4
Internal Consistency and Validity of a Theory	6
QGD's Axiom Set.....	7
Principle of Strict Causality:	9
Fundamentality and the Conservation Law	9
Quantum-Geometrical Space	10
The Nature of Space	10
<i>Theorem on the Emergence of Euclidian Space from Quantum-Geometrical Space</i>	14
Application of the Theorem of Emergent Space	15
Interactions between Preons ⁽⁻⁾	15
Properties of Preons ⁽⁻⁾	16
Emerging Space and the Notion of Dimensions	16
Conservation of Space.....	17
The Concept of Time.....	19
The Quantum-Geometrical Nature of Matter	20
Preon ⁽⁺⁾ Preon ⁽⁺⁾ pairs	20
Propagation.....	21
Interaction.....	21
Mass, Energy, Momentum of Particles and Structures.....	21
Mass	21
Energy	22
Momentum	22
Velocity	23

Heat, Temperature and Entropy.....	23
Application to Exothermic Reactions within a System	24
The Velocity of Light and Preons ⁺	26
Time Distance Equivalence.....	26
Physical Interpretation of the Equal Sign in Equations.....	27
The Relation between Objects and Scales	29
Forces, Interactions and Laws of Motion	30
Gravitational Interactions and Momentum	30
Gravitational Dynamics.....	31
Derivation of Newton's Law of Gravity.....	31
The Fundamental Momentum and Gravity	32
Gravity between Particles and Structures	33
Derivation of the Weak Equivalence Principle	35
Comparison between the Newtonian and QGD Gravitational Accelerations	37
Non-Gravitational Interactions and Momentum.....	38
Application to Celestial Mechanics	39
Transfer and Conservation of Momentum	43
Electromagnetic Effects.....	48
The Electromagnetic Effects of Attraction of Repulsion	49
Preonics (foundation of optics).....	56
Reflection of Light	56
Refraction of Light.....	57
Diffraction of Light.....	59
Fringe Patterns from Double-slit Experiments.....	60
Single Slit Experiment	61
Double-Slit Experiments.....	61
QGD at Short Distances	64
The Gravitational Effect at Very Small Distances	64
Electromagnetic Interactions between Nucleons	65

Nuclear Interactions and the Law and Momentum	66
Principle of Strict Causality and Equilibrium	68
QGD Interpretations of Redshift Effects.....	69
Intrinsic Redshift	69
Predictions for Relative Gravitational Redshift.....	70
What the Redshift Tells Us.....	71
Mapping the Universe	74
Distances and Intrinsic Luminosities of 1a Supernovas	75
Derivation of the Intrinsic Velocity of Earth from Type 1a Supernovas.....	75
Derivations of Predictions of Special and General Relativity	76
Constancy of the Speed of Light.....	76
Why nothing can move faster than the speed of light.....	76
The Relation between Speed and the Rates of Clocks	76
The Relation between Gravity and the Rates of Clocks.....	79
Predictions	79
Bending of light.....	80
Precession of the Perihelion of Mercury.....	81
About the Relation Between Mass and Energy.....	84
Implications	85
Other Consequences of QGD's Gravitational Interaction Equation	87
Dark Photons and the CMBR	87
Effect Attributed to Dark Matter.....	87
Effect Attributed to Dark Energy	88
Einstein's Equivalence Principle	89
Weightlessness in Einstein's thought Experiment	92
Gravitational Waves	94
Locality, Certainty and Simultaneity	97
Locality and Instantaneous Effects	97
Instantaneity and the Uncertainty Principle	97

Position and Momentum of Particles (or Structures).....	97
The Notion of Simultaneity.....	101
Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?	102
States of Atomic Electrons	105
The Zeeman Effect.....	106
States of Muonic Hydrogen.....	107
Determination of the Proton Size.....	107
Radius of a Proton	108
The Photoelectric Effect.....	108
Conclusion.....	108
QGD Equations Applicability	109
Assigning Value to k	109
Assigning Value to c	109
Alternative Measurements of Earth's Intrinsic Speed	113
Measurements of the Intrinsic Speed of a Distant Light Source	114
QGD Cosmology	115
The Initial or Isotropic State.....	115
Heat, Temperature, Energy of the Initial State	115
Cosmic Microwave Background Radiation (1st observable state)	116
Particle Formation and Large Scale Structures.....	117
Galaxy Formation, Motion, Shape and Evolution	119
Galaxy Dynamics.....	120
Dark Matter Halo Density Distribution.....	120
Rotation Curve of Galaxies	121
Recession Speed between Large Structures	122
Expansion Rate of the Material Universe and the Cosmological Redshift	123
Black Holes and Black Holes Physics.....	124
Angle between the Rotation Axis and the Magnetic Axis	124
The Inner Structure of Black Holes.....	125

Density and Size of Black Holes.....	127
Neutron Stars, Pulsars and Other Supermassive Structures.....	128
Pulsars	128
The Preonic Universe.....	128
Future Evolution of the Universe	130
QGD Interpretations of Quantum Entanglement Experiments.....	131

I wish merely to point out the lack of firm foundation for assigning any physical reality to the conventional continuum concept. My own view is that ultimately physical laws should find their most natural expression in terms of essentially combinatorial principles, that is to say, in terms of finite processes such as counting or other basically simple manipulative procedures. Thus, in accordance with such a view, should emerge some form of discrete or combinatorial space-time.

Roger Penrose, On the Nature of Quantum-Geometry

Hilbert's 6th problem

In 1900, the famous mathematician David Hilbert introduced a list of 24 great problems in mathematics. The list of problems addressed a number of important issues in mathematics; many of which have remained to this day unresolved. Hilbert's 6th problem, which has become central to physics, reads as follow:

To treat in the same manner, by means of axioms, those physical sciences in which already today mathematics plays an important part; in the first rank are the theory of probabilities and mechanics.

Though it was not a consideration at the time of its formulation, Hilbert's 6th problem is really about creating a [theory of everything](#).

The approach suggested by Hilbert's problem was to create a finite and complete set of axioms from which all the governing laws of the Universe could be derived. He suggested that a physics theory be an axiomatic system; that is, a theory that is founded on axioms from which all physics can be deduced from or reduced to.

An axiom, as most of you know, is a fundamental assumption or proposition about a domain. What this means is that it can't be reduced, derived or deduced from any other propositions. In other words, an axiom cannot be mathematically proven.

Though, Gödel's incompleteness theorems demonstrates that not all propositions, theorems and corollaries can be deduced from the set of axioms associated with a specific domain, they doesn't preclude the existence of a complete and consistent set of axioms in physics.¹

In physics, axioms are understood as representing fundamental properties or components of reality. My understanding of Hilbert's 6th problem is that a set of axioms about physical reality that is complete be created. That is, all observations, any and all phenomena could be deduced from the set of axioms. The set of axioms and laws, explanations and predictions deduced from it would form an axiomatic system or axiomatic theory which would axiomatize the whole of physics.

It seems evident that the purpose of physics is to identify the fundamental properties or components of reality and to use them to develop theories that can explain observations of

¹ See [Do Gödel's Incompleteness Theorems Exclude the Possibility of a Theory of Everything?](#)

physical phenomena. What is less evident is how to determine when the propositions chosen by physicists to be the basis of a theory are really axioms.

While in mathematics one can arbitrarily chose any consistent set of axioms as a basis of an axiomatic system, the axioms in a physics theory must represent fundamental aspects of reality. This raises the essential question: What constitutes a fundamental aspect of reality?

As we will see in this book, quantum-geometry dynamics proposes that reality obeys a principle of strict causality. From the principle of strict causality, it follows that an aspect of reality is fundamental if it is absolutely invariable. That is, regardless of interactions or transformations it is subjected to, a fundamental aspect of reality remains unaffected.

Now that we established what we mean by a fundamental aspect of reality, two presuppositions need to be accepted in order to answer Hilbert's 6th problem. First, we must assume that the Universe is made of fundamental objects having properties which determine a consistent set of fundamental laws. Second, that it can be represented by a complete and consistent axiomatic system. That is, the Universe has a finite set of fundamental components which obey a finite set of fundamental laws. These two presuppositions are essential for the construction of any true axiomatic system.

In addition to the two presuppositions, there is also the question of the minimum axiom set necessary to form a complete and consistent axiomatic theory.

To determine that value, we need to remember that the number of constructs that can be built from a finite set of fundamental objects is always greater than the number of objects in the set.

If, for example, the number of objects in the fundamental set is equal to n , and the number of ways they can be assembled by applying laws of combination is equal to l then the number of objects that can be formed is equal to

$$l \propto n!^j$$

where j is the maximum number of objects which can be combined. From this, we can see that the closer we get to fundamental reality, the lower l becomes, the simpler reality becomes; with reality being at its simplest at the fundamental scale. What this implies is that any axiomatic theory of reality will have fewer fundamental components than constructs. It follows that a theory must allow for an exponentially greater number of composite structures than it has elementary particles.

In plain language, reality at the fundamental scale is simpler, not more complex.

So, what is the smallest possible set of axioms an axiomatic theory of fundamental physics can have?

Before answering this question, quantum-geometry dynamics first asks: What does everything in the Universe have in common? What does every single theory of physical reality ever conceived of have in common?

The answer: space and matter. Space and matter are aspects of reality shared by everything, all phenomena, all events in the Universe. It follows that any axiomatic theory of physical reality must minimally account for space and matter. Quantum-geometry dynamics, which is the subject of this book, is derived from the following two axioms.

Space is made of discrete fundamental units, $preons^{(-)}$, and is dimensionalized by the intrinsic repulsion force acting between them.

Matter is made of fundamental strictly kinetic particles, the $preons^{(+)}$, which form particles and structures as a result of the intrinsic attractive force acting between them.

Two Ways to do Science

From an axiomatic standpoint, there are two only two ways to do theoretical physics. The first aims to extend, expand and deepen an existing theory; which is what the overwhelming majority of theorists do. This approach assumes that the theory is fundamentally correct, that is, its axioms are thought to correspond to fundamental aspects of reality.

The second way of doing theoretical physics is to create a new axiom set and derive a theory from it. Distinct axiom sets will lead to distinct theories which, even if they are mutually exclusive may still describe and explain phenomena in ways that are consistent with observations. There can be a multiplicity of such “correct” theories if the axioms are made to correspond to observed aspects of physical reality that are not fundamental but emerging. For instance, theories have been built where one axiom states that the fundamental component of matter is the atom. Such theories, though it may describe very well some phenomena at the molecular scale will fail in explaining a number of phenomena at smaller scales. In the strict sense, premises based on emergent aspect of reality are not axioms in the physical sense. They can better be understood as theorems. And as mathematical theorems in mathematics can explain the behavior of mathematical objects belonging to a certain class but cannot be generalized to others, physical theorems can explain the behavior of class of objects belonging to a certain scale but these explanations cannot be extended to others scales or even to objects or other classes of objects in the same scale.

But axiom sets are not inherently wrong or right. By definition, since axioms are the starting point, they cannot be reduced or broken down. Hence, as such, we cannot directly prove whether they correspond to fundamental aspects of reality. However, if the models that emerge from an axiom set explain and describe reality and, most importantly, allows predictions that can be tested, then confirmation of the predictions become evidence supporting the axiom set.

The Axiomatic Approach

It can scarcely be denied that the supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible without having to surrender the adequate representation of a single datum of experience.

Albert Einstein

The dominant approach in science (and a hugely successful one for that matter) is the empirical approach. That is, the approach by which science accumulates data from which it extracts relationships and assumptions that better our understanding of the Universe.

The empirical approach is an essential part of what we might call deconstructive. By that I mean that we take pieces or segments of reality from which, through experiments and observations, we extract data from which we hope to deduce the governing laws of the Universe. But though the deconstructive approach works well with observable phenomena, it has so far failed to provide us with a complete and consistent understanding of fundamental reality.

Of course, when a theory is formulated that agrees with a data set, it must be tested against future data sets for which it makes predictions. And if the data disagrees with predictions, the theory may be adjusted so as to make it consistent with the data. Then the theory is tested against a new or expanded data set to see if it holds. If it doesn't, the trial-and-error process may be repeated so as to make the theory applicable to an increasingly wider domain of reality.

The amount of data accumulated from experiments and observations is astronomical, but we have yet to find the key to decipher it and unlock the fundamental laws governing the Universe.

Also, data is subject to countless interpretations and the number of mutually exclusive models and theories increases as a function of the quantity of accumulated data.

But, more to the point, what if fundamental reality is orders of magnitude smaller than the smallest observable scale we can probe? Should this be the case, an axiomatic approach may then be our only hope to gain insight into the workings of reality at the fundamental scale.

About the Source of Incompatibilities between Theories

Reality can be thought as an axiomatic system in which fundamental aspects correspond to axioms and non-fundamental aspects correspond to theorems.

The empirical method is essentially a method by which we try to deduce the axiom set of reality, the fundamental components, and forces, from theorems (non-fundamental interactions). There lies the problem. Even though reality is a complete and consistent system, the laws extracted from observations at different scales of reality and which form the basis of physics theories do not together form a complete and consistent axiomatic system.

The predictions of current theories may agree with observations at the scale from which their premises were extracted, but they fail, often catastrophically, when it comes to making predictions at different scales of reality.

This may indicate that current theories are not axiomatic; they are not based on true physical axioms, that is; the founding propositions of the theories do not correspond to fundamental aspects of reality. If they were, then the axioms from distinct theories could be merged into a consistent (but not necessarily complete) axiomatic set. There would be no incompatibilities.

Also, if theories were axiomatic systems in the way we described above, their axioms would be similar or complementary. Physical axioms can never be in contradiction.

This raises important questions about the empirical method and its potential to extract physical axioms from the theorems it deduces from observations. The fact that even theories which are derived from observations of phenomena at the microscopic scale have failed to produce *physical axioms* (if they had, they would explain interactions at larger scales as well) suggests that there is a distinction between the microscopic scale, which is so relative to our scale, and the fundamental scale which may be any order of magnitude smaller.

There is nothing that allows us to infer that the microscopic scale which is assumed to be fundamental is truly fundamental scale or that what we observe at the microscopic scale is fundamental. It may very well be that everything we hold as fundamental, the particles, the forces, etc., are not.

Also, theories founded on theorems related to different scales rather than axioms cannot be unified. It follows that the grand unification of the reigning theories which has been the dream of generation of physicists is mathematically impossible. A theory of everything cannot result from the unification of the standard model and relativity, for instance, them being based on mutually exclusive axiom sets. Therefore, it is essential to rigorously derive any axiomatic theory from its axiom set and avoid at all times the temptation of contriving it into agreeing with other theories.

So even though, as we will see later, Newton's law of universal gravity, the laws of motion, the universality of free fall and the relation between matter and energy can all be derived from QGD's axiom set, deriving them was never the goal when the axiomatic set was chosen. These laws just followed naturally from QGD's axiom set.

However, an axiomatic approach as we have described poses two important obstacles.

The first is choosing a set of axioms where each axiom corresponds to a fundamental aspect of reality if fundamental reality is inaccessible thus immeasurable.

The second obstacle is how to test the predictions of an axiomatically derived theory when the scale of fundamental reality makes it immeasurable.

In the following chapters, we will see that even in the likely scenario that fundamental reality is unobservable, if the axioms of our chosen set correspond to fundamental aspects of reality then there must be inevitable and observable consequences at larger scales which will allow us to derive unique testable predictions. We will show that it is possible to choose a complete and consistent set of axioms, that is one from which interactions at all scales of reality can be reduced to. In other words, even if the fundamental scale of reality remains unobservable, an axiomatic theory would make precise predictions at scales that are.

Internal Consistency and Validity of a Theory

Any theory that is rigorously developed from a given consistent set of axioms will itself be internally consistent. That said, since any number of such axiom sets can be constructed, an equal number of theories can be derived that will be internally consistent. To be a valid axiomatic physics theory, it must answer positively to the following questions.

1. Do its axioms form an internally consistent set?
2. Is the theory rigorously derived from the axiom set?
3. Are all descriptions derived from the theory consistent with observations?
4. Can we derive explanations from the axiom set that are consistent with observations?
5. Can we derive from the axiom set unique and testable predictions?

And if an axiom set is consistent and complete, then:

6. Does the theory derived from the axiom set describe physical reality at all scales?

In the following chapters, we will see how quantum-geometry dynamics answers these questions.

QGD's Axiom Set

For several decades now, mathematicians and physicists have tried to reconcile quantum mechanics and general relativity, two of the most successful physics theories in history, but despite their best efforts such unification has remained beyond the limit of the scientific horizon.

The problem, we believe, stems from the fact that the axiom sets of quantum-mechanics and general relativity are mutually exclusive. It is a mathematical certainty that unification of axiom sets which contain mutually exclusive axioms is impossible, as is the unification of the theories derived from them. In other words, though it may be possible to unify quantum mechanics and general relativity, it cannot be done without abandoning some of the axioms of their respective axiom sets, but abandoning any of the axioms amounts to giving up on one, if not both theories. However, it is impossible to give up on one without giving up on the other since both are necessary to describe reality at all scales. Hence the impasse physicists have struggled with. Unification of the two theories requires that their axiom sets be unified, which in turn requires that their axioms be complementary and not, as are those of QM and GR, exclusory. QM and GR cannot be reconciled without abandoning some of their fundamental assumptions.

We propose here an alternative approach. Intuiting that at its most fundamental, reality is also at its simplest, we construct the simplest possible axiom set that can describe a dynamic system; one where each axiom corresponds to a fundamental aspect of reality agreed upon by all theories of physics. That is, the existence of space and the existence of matter. We will show that from such a minimal set of axioms a theory can be developed that describes and explains all physical phenomena, thus is in agreement with the predictions of quantum-mechanics and general relativity. Most importantly, a theory that is in complete agreement with physical reality.

The idea is to create an absolute minimal dynamic system and explore how such a system will evolve from an initial state. The choices of the minimal components of a dynamic system and their properties will constitute axioms from which theorems will be derived that will predict how such a system will evolve. One should not assume that the axioms and theorems correspond to fundamental aspects to physical reality unless the dynamic system they describe evolves into one that is analogous to observable reality.

It is evident that such a system must exist in space, but space could be continuous or discrete, static or dynamic. Here we chose space to be fundamentally discrete. We will call the fundamental discrete units or particles of space *preons*⁽⁻⁾.

Preons⁽⁺⁾ do not exist in space, they are space, yet each of them is distinct, that is, they each correspond to a distinct location. We will assume that *preons*⁽⁻⁾ are kept apart from each other by a repulsive force acting between them which we will call n-gravity. So between *preons*⁽⁻⁾ is not space but the n-gravity field. Therefore, *preons*⁽⁻⁾ exists in the n-gravity field. Also, it follows

that $preons^{(-)}$ must static since movement would require that they move in space, that is, that they exist in space and that would contradict the defining assumptions.

Next, we need matter and since matter must exist in space and our space is discrete, then it follows that the matter in the dynamic system we are creating must also be discrete or corpuscular. And since our system is minimal, we have only one fundamental unit of matter, one type of fundamental particle which we will call $preons^{(+)}$. If $preons^{(+)}$ are to interact to form more massive particles and structures, then they need to be kinetic and they need to be capable of binding with one another. $Preons^{(+)}$ will therefore be assumed to move by “leaping” from $preons^{(-)}$ to $preons^{(-)}$ thus have momentum. The momentum of a $preon^{(+)}$ will be the fundamental unit of momentum and the displacement between two $preons^{(-)}$ the fundamental unit of displacement.

For $preons^{(+)}$ to bind into particles and structures, there must be an attractive force acting between them. We will call that force, p-gravity.

Since in our minimal system we have only one fundamental particle of matter, there are no other particles a $preon^{(+)}$ can decay into or be formed from. $Preons^{(+)}$ are eternal, hence their number is finite. The same goes for $preons^{(-)}$.

As for the initial state, we will define it as one in which $preons^{(+)}$ are free and homogeneously distributed in discrete space.

Other minimal systems can be constructed and different initial states can be chosen for each, but the above is the only one we will explore here. I have called the study of the evolution of this minimal system *quantum-geometry dynamics*.

Minimal Axiom Set

From a minimal set of axiom we can derive dynamics systems which behaviour find their counterparts in nature.

Axiom 1: We define quantum-geometrical space as that which emerges from the repulsive interactions between fundamental quanta of space we will call $preons^{(-)}$.

Axiom 2: We define quantum-geometrical matter as that which is formed by the binding of fundamental particles of matter through an attractive force acting between them. We will call the fundamental particles of matter $preons^{(+)}$

Axiom 3: The initial state of the quantum-geometrical universe is that in which $preons^{(+)}$ where uniformly distributed through quantum-geometrical space.

Axiom 4: *A quantum-geometrical particle is fundamental if it never decays or transmutes into other particles. Preons⁽⁻⁾ and preons⁽⁺⁾ are the only fundamental particles that exist in the quantum-geometrical universe.*

Principle of Strict Causality:

All successive states of a particle, structure or system are strictly and uniquely causally linked.

The principle of strict causality being based on properties of physical reality, it offers the possibility of understanding the evolution of the Universe as sequences of events that are causally connected. Strict causality effectively allows a description of the evolution of any system without having to resort to the relational concept we call time.

The principle of strict causality implies is that the Universe does not evolve with time, but changes from one state to another as a consequence of concurrent causally related series of events.

Fundamentality and the Conservation Law

What is considered fundamental has often changed over the course of History so that often what at some time we have consider fundamental ultimately revealed itself to be non-fundamental. How we define "fundamental" has profound consequences on the way we interpret reality or create models. QGD uses the following definition:

An aspect of reality is fundamental if it is absolutely invariant

Thus, if an object is fundamental its intrinsic properties are conserved throughout the existence of the Universe.

Strict causality excludes spontaneity which assumes that a particle or system can change for no other reason that over time there is a probability that it will. It implies that when a particle decays into other particles and no external interaction affected that change, then the change must be caused by internal interactions, which in turn imply structure, so that the particle is not elementary.

It also implies that if a particle is elementary, that is, has no structure, hence no internal interactions which can cause it to change, then it can never decay.

Quantum-Geometrical Space

Let me say at the outset that I am not happy with this state of affairs in physical theory. The mathematical continuum has always seemed to me to contain many features which are really very foreign to physics. [...] If one is to accept the physical reality of the continuum, then one must accept that there are as many points in a volume of diameter 10^{13} cm or 10^{33} cm or 10^{1000} cm as there are in the entire universe. Indeed, one must accept the existence of more points than there are rational numbers between any two points in space no matter how close together they may be. (And we have seen that quantum theory cannot really eliminate this problem, since it brings in its own complex continuum.)

Roger Penrose, On the Nature of Quantum-Geometry

The Nature of Space

I consider it quite possible that physics cannot be based on the field concept, i. e., on continuous structures. In that case nothing remains of my entire castle in the air, gravitation theory included, [and of] the rest of modern physics. - Einstein in a 1954 letter to Besso.

What Einstein might have been referring to is that special relativity and general relativity require that space be continuous. The axiom of continuity of space is implied by special relativity as well as most current physics theory.

Einstein understood that if the implied continuity axiom turned out not to correspond to the fundamental nature of space, his theory and all theories which are based on it would also fall apart. We disagree. Einstein's theories would still hold very well if space were discrete rather than continuous, and so would be the principle of relativity.

When considering that predictions of the relativity theories have been confirmed by countless experiments and observations, it is logical to assume that their underlying axioms must be correct, including that of space continuum which is an implicit axiom. And space continuum and space discreteness being mutually exclusive, if space were discrete, then it would follow that space continuum and theories founded on it would be wrong, right? But what if the space continuum was not fundamental? What if space only appears and behaves to be continuous at larger than the fundamental scale allowing physical theories such as the relativity theories to correctly describe systems at those scales. Then space continuum would not be an axiom in the sense we have described [here](#), but a theorem. That could explain why general relativity can correctly describe dynamic systems at large scales while failing for systems at the fundamental scale where space would be discrete. If this were the case, then understanding how the space continuum emerges from discrete space would open the door to fundamental theories that can describe dynamics systems in discrete space while still being compatible with theories such as general relativity.

Dominant theories successfully explained and predict phenomena at scales which they observed and from which observations their theorems were derived. Space continuum is what is observed at non-fundamental scales.

Quantum-geometry dynamics postulates that space is fundamentally discrete. Specifically, that space is quantum-geometrical, that is: Quantum-geometrical space is formed by fundamental particles we call $preons^{(-)}$ (symbol $p^{(-)}$) and is dimensionalized by the repulsive force acting between them. Thus according to QGD, spatial dimensions are emergent properties of $preons^{(-)}$, hence dimensionalized space is not fundamental.

The interaction between any two $preons^{(-)}$ is the fundamental unit of the force acting between them which because it is repulsive, we will call n-gravity (symbol g^{-}).

It is important here to remind the reader that what exists between two $preons^{(-)}$ is the n-gravity field of interactions. There is no space in the geometrical sense between them. The force of the field between any two $preons^{(-)}$, anywhere in the Universe, is equal to one g^{-} .

Figure 1 is a two-dimensional representation of quantum-geometrical space. The green circle represents a $preon^{(-)}$ arbitrarily chosen as origin and the blue circles represent $preons^{(-)}$ which

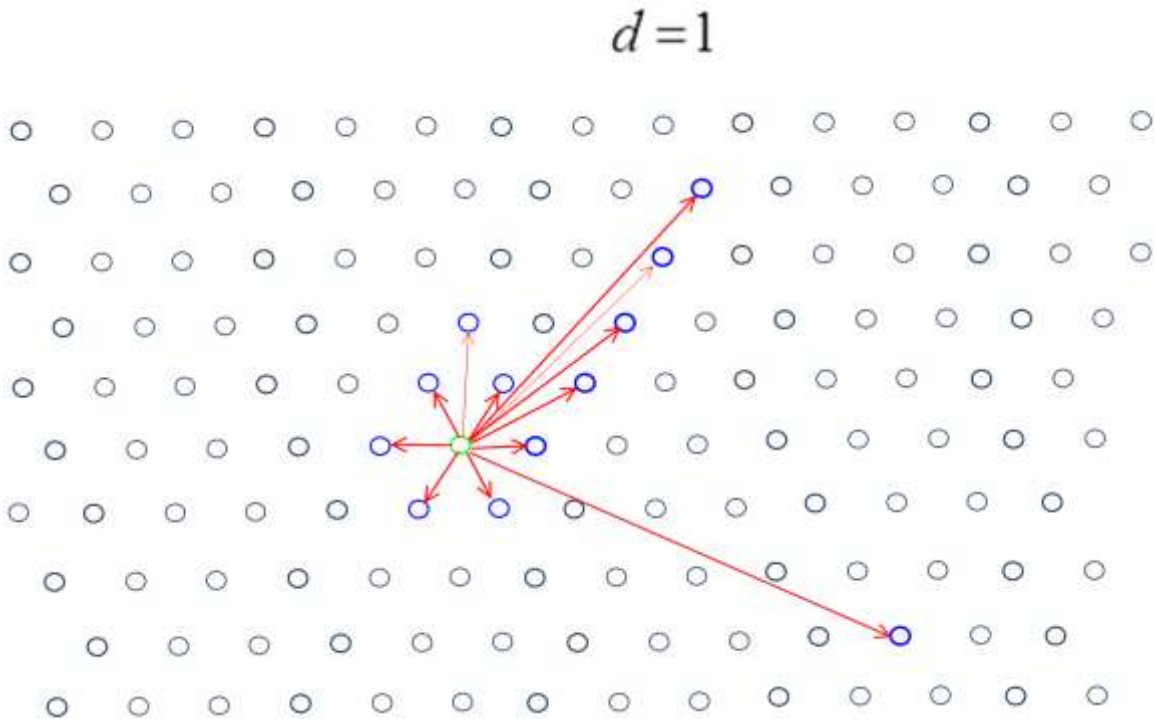


Figure 1

are all at one unit of distance from it. As we can see, distance in quantum-geometrical space at the fundamental scale is very different than Euclidian distance (though we will show below that Euclidian geometry emerges from quantum-geometrical space at larger scales).

Quantum-geometric space is not merely mathematical or geometrical but physical. Because of that, to distinguish it from quantum-geometrical space, we will refer to space in the classical sense of the term as *Euclidian space*.

Quantum-geometric space is very different from metric space. A consequence of this is that the distance between any two $preons^{(-)}$ in quantum-geometric space is be very different from the measure of the distance using Euclidian space; the distance between two points or $preons^{(-)}$ being equal to the number of leaps a $preon^{(+)}$ would need to make to move from one to the other.

In order to understand quantum-geometric space, one must put aside the notion of continuous infinite and infinitesimal space. Quantum-geometrical space emerges from the n-gravity interactions between $preons^{(-)}$. What that means is that $preons^{(+)}$ do not exist in space, they are space. Since $preons^{(-)}$ are fundamental and since QGD is founded on the principle of strict causality (this will be discussed in detail later), then the n-gravity field between $preons^{(-)}$ has always existed and as such may be understood as instantaneous. N-gravity does not propagate. It simply exists.

Figure 2 shows another example of how the distance between two $preons^{(-)}$ is calculated. So, although the Euclidian distance between the green $preon^{(-)}$ and any one of the blue $preons^{(-)}$ are nearly equal, the quantum-geometrical distances between the same varies greatly.

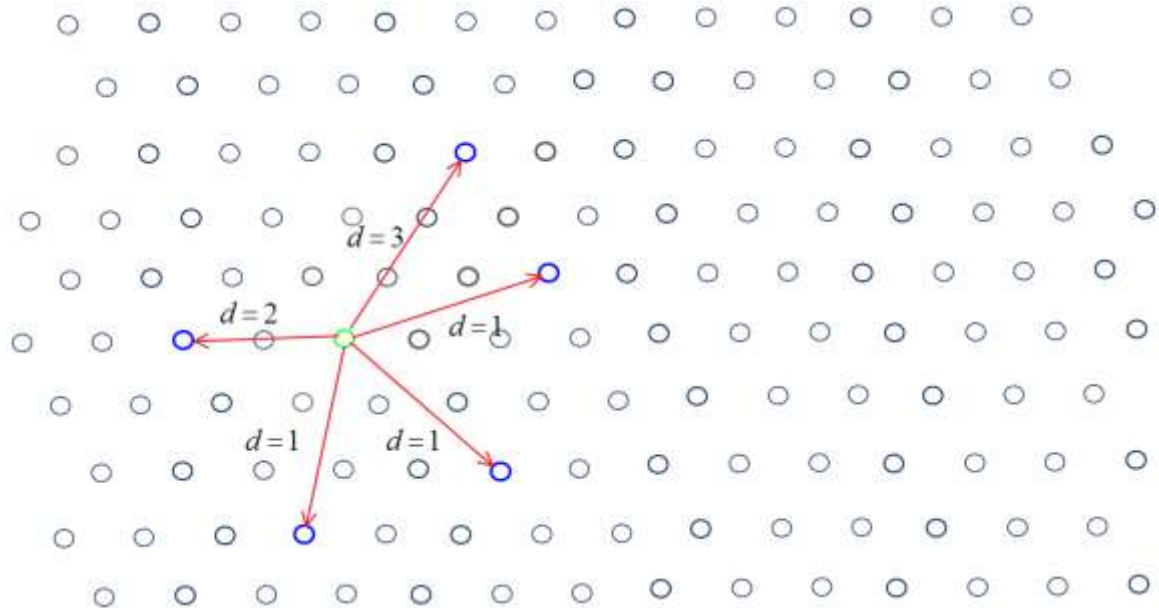


Figure 2

Since the quantum-geometrical distances do not correspond to the Euclidian distances, the theorems of Euclidean geometry do not hold at the fundamental scale. Trying to apply

Pythagoras's theorem to the triangle which in the figure 3 below defined by the blue, the red and the orange lines, we see that $a^2 + b^2 \neq c^2$.

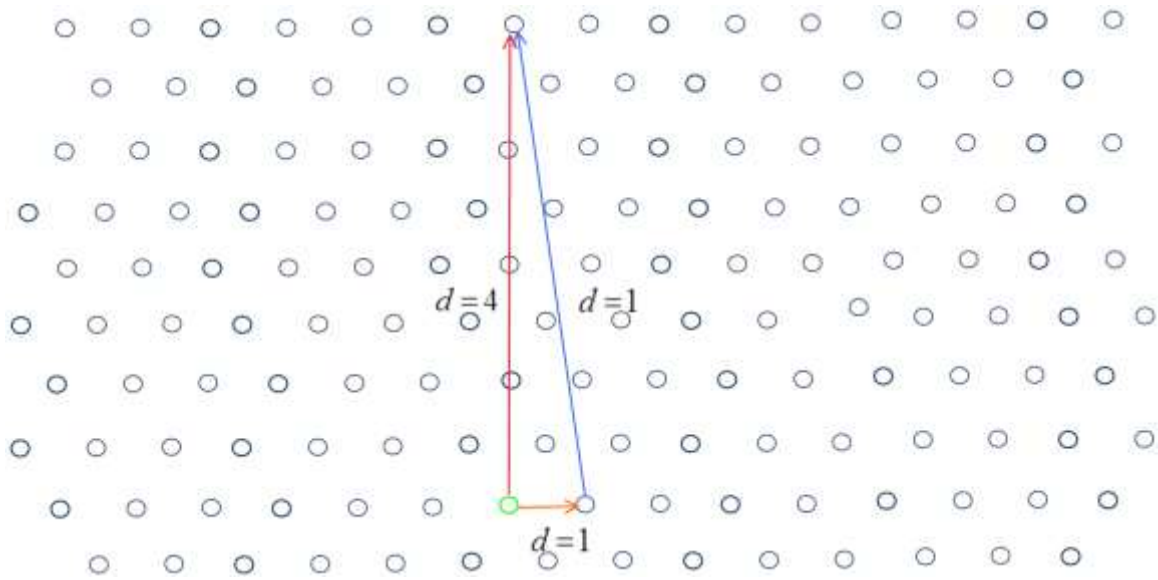


Figure 3

Also interesting in the figure 3 is that if a is the orange side, b the red side and c the blue side (what would in Euclidian geometry be the hypotenuse, then $a + c < b$. That is, the shortest distance between two $preons^{(-)}$ is not necessarily the straight line.

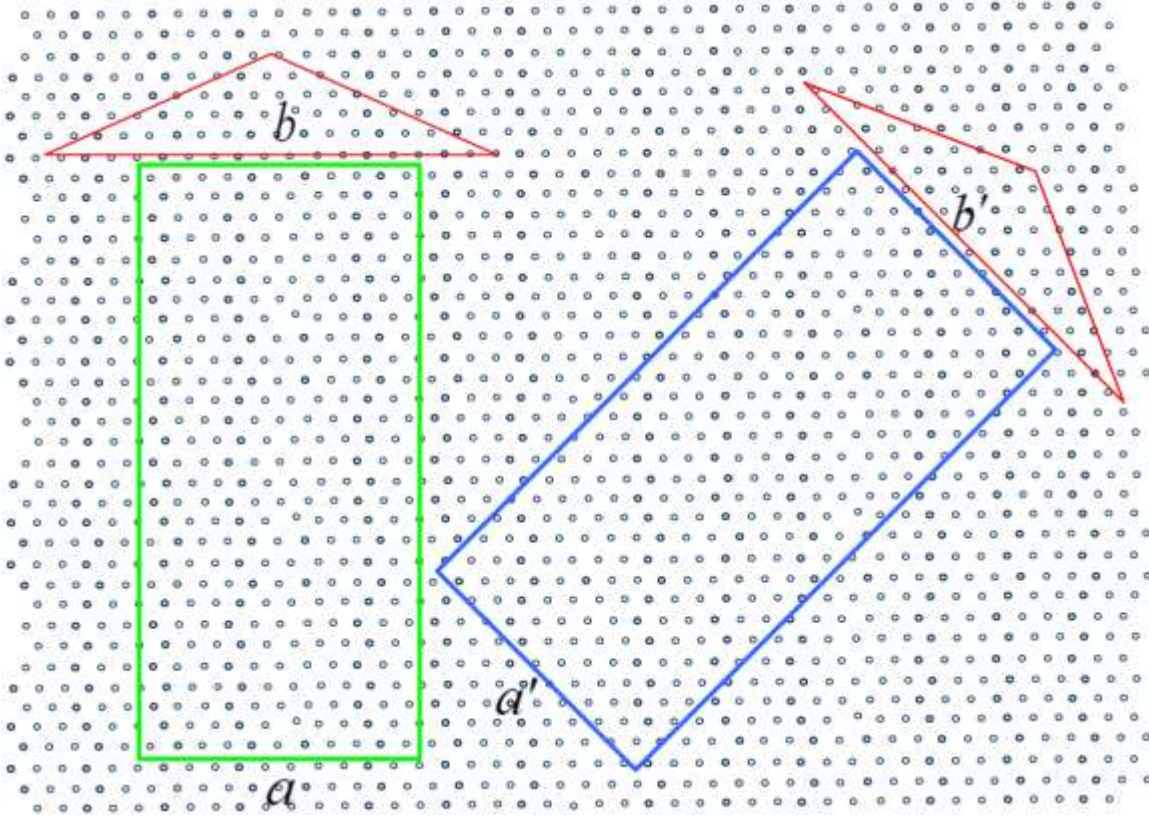


Figure 4

But we evidently live on a scale where Pythagoras's theorem holds, so how does Euclidian geometry emerge from quantum-geometrical space? Figure 4 shows the quantum-geometrical space two identical objects scan when moving in different directions.

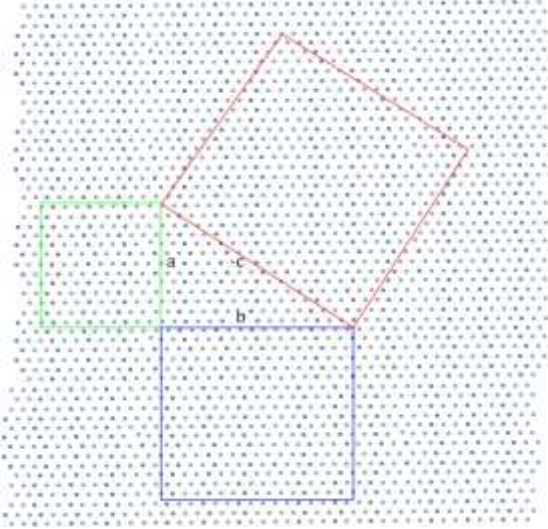
Here, if we consider that the area in the blue rectangles is made of all the $preons^{(-)}$ through which the object moves, we see that as we move to larger scales, the number $preons^{(-)}$ contained in the green rectangle approaches the number of $preons^{(-)}$ in the blue rectangle, so that if the distance from a to b or from a' to b' is defined by the number of $preons^{(-)}$ contained in the respective rectangles divided by the width of the path, we find that $a \rightarrow b \simeq a' \rightarrow b'$.

Theorem on the Emergence of Euclidian Space from Quantum-Geometrical Space

If d and d_{Eu} are respectively the quantum-geometrical distance and the Euclidean distance two $preons^{(-)}$, then $\lim_{d \rightarrow \infty} d - d_{Eu} = 0$.

The theorem implies that beyond a certain scale the Euclidian distance between two points becomes a good approximation of the quantum-geometrical distance, but that below that scale, the closer we move towards the fundamental scale, the greater the discrepancies between the Euclidian and quantum-geometrical measurements of distance. A direct consequence of the structure of space and the derived theorem is that Euclidean geometric figures are ideal objects that though they can be conceptualized in continuous space can only be approximated in quantum-geometrical space to the resolution corresponding to the fundamental unit of distance.

It is important to note that since there are no infinities in QGD, the infinite sign ∞ is an impossibly large distance, hence the difference between quantum-geometrical and Euclidean distances, though it can very large or insignificantly small, can never be infinite or even equal to zero.



In figure 5, if n_1 , n_2 and n_3 are respectively the number of parallel trajectories that sweep the squares a , b and c , for $n_{1-3} > M$, then

$$\bar{a} \approx \frac{\sum_{i=1}^{n_1} d_i}{n_1}, \quad \bar{b} \approx \frac{\sum_{i=1}^{n_2} d_i}{n_2} \text{ and } \bar{c} \approx \frac{\sum_{i=1}^{n_3} d_i}{n_3} \text{ so that}$$

$\bar{a}^2 + \bar{b}^2 \approx \bar{c}^2$. Hence, given the quantum-geometrical length of the sides of any two of the three squares above, Pythagoras's theorem can be used to calculate an approximation of a the length of the side of the third. Also, the greater

the values of n_1 , n_2 and n_3 the closer the approximation will be to the actual unknown length.

$$\text{That is } \lim_{\substack{n_1 \rightarrow \infty \\ n_2 \rightarrow \infty \\ n_3 \rightarrow \infty}} (\bar{a}^2 + \bar{b}^2) = \bar{c}^2.$$

Application of the Theorem of Emergent Space

Even though reality at the fundamental scale is discrete, the theorem of emergence of Euclidean space allows us to use of continuous mathematics to describe dynamic systems at larger scales. We must however keep in mind that however accurate they may be, calculations using continuous mathematics remain approximations of the behaviour of the discrete components that form dynamics systems taken as a group and that quantum-geometrical reality only admits integer values of physical properties.

Interactions between Preons⁽⁻⁾

We mentioned earlier that the interactions between two adjacent $preons^{(-)}$ is repulsive and the fundamental unit of n-gravity. Two $preons^{(-)}$ are adjacent if there is no other $preons^{(-)}$ between

them. So for two $preons^{(-)}$, a and b , $G(a;b) = 1 \ g^-$ where $G(a;b)$ is the magnitude of the n-gravity interaction between them.

To obtain the magnitude of the n-gravitational interaction between any two $preons^{(-)}$ a and b , we need to take into account the interactions with and between the $preons^{(-)}$ that lie on the line of force connecting them. Thus, we need to count the number of interactions. Using the simple combinatory formula, we find that the magnitude of the n-gravitational interaction between any two $preons^{(-)}$ is

$$G^-(a;b) = \frac{d^2 + d}{2} g^- \quad (1)$$

where d is the distance measure in number of $preons^{(-)}$ between a and b .

We will show in a [later section](#) that the repulsive force between space and matter is consistent with the effect we attribute to dark energy.

Properties of Preons⁽⁻⁾

$Preons^{(-)}$ do not exist in space, they are space. This implies since any motion would imply that they would themselves be in space, which would contradict the 1st axiom, then they must be static.

And since they are fundamental, $preons^{(-)}$ do not decay into other particles the number of $preons^{(-)}$ is finite and constant which implies that quantum-geometrical space is finite, and that the Universe is finite.

Emerging Space and the Notion of Dimensions

We think of spatial dimensions as if they were physical in the way matter and space are physical, but the concept of dimensions is a relational concept which allows us to describe of the motion (even if that motion is nil) of an object or set of objects a relative to an object or set of objects b taken as a reference. Different systems of reference having directions and speeds relative to a given object or set of objects give different measurements of their positions, speed, mass and momentum and, according to dominant physics theories, there is no way to describe the motion of a reference system relative to space (or absolute motion), thus no way to know anything but relative measurements of properties are such as mass, energy, speed, momentum or position.

However, if QGD is correct in its description of space, then each fundamental unit of space is a distinct permanent position relative to all other discrete components of space ($preons^{(-)}$ being static) so that quantum-geometrical space can be taken as an absolute reference system which

The dimensionality of quantum-geometrical space (physical space) is the maximum number of elements in a set of non-concurrent and mutually orthogonal lines that have a common a *preon*⁽⁻⁾ . Space being an emergent property of *preons*⁽⁻⁾ and all *preons*⁽⁻⁾ having identical fundamental intrinsic properties, and all interacting to create space, then space must be isotropic.

Conservation of Space

That quantum-geometrical space is not infinitesimal also implies that geometric figures are not continuous either. For example, a circle in quantum-geometric space is a regular convex polygon whose form approaches that of the Euclidian circle as the number of *preons*⁽⁻⁾ defining its vertex increases. That is, the greater the diameter of the polygon, the more its shape approaches that of the Euclidean circle (a similar reasoning applies for spheres).

The circumference of a circle in quantum-geometric space is equal to the number of triangles with base equal to 1 leap which form the perimeter of the polygon. It can also more simply be defined as the number of *preons*⁽⁻⁾ corresponding to the polygon's vertex.

Since both the circumference of a polygon and its diameter have integer values, the ratio of the first over the second is a rational number. That is, if we define π as the ratio of the circumference of a circle over its diameter, then π is a rational function of the circumference and diameter of a regular polygon.

This implies that in quantum-geometric space the calculation of the circumference or area of a circle or the surface or volume of the sphere can only be approximated by the usual equations of Euclidian geometry.

The surface of a circle would be equal to the number of *preons*⁽⁻⁾ within the region enclosed by a circular path.

From the above we understand that π , the ratio of the circumference of a circle over its diameter, is not a constant as in Euclidean geometry, but a function. If $\pi(a)$ is the proportionality function between the apothem a of the polygon and its perimeter then, since the base of the triangles that form the perimeter is equal to 1, it follows that the size of the polygon increases the value of the apothem of the polygon approaches the value of its circumradius and $\pi(a)$ approaches the geometrical value of π . Note that the smallest possible circumradius is equal to 1 leap, which defines the smallest possible circle which has six vertexes. Since in this case $2\pi r = 6$ and $r = 1$ it follows that $\pi(1) = 3$ $\pi(1) = 3$.

$$\pi(a) = n / 2a$$

$$\lim_{a \rightarrow \infty} \pi(a) = \pi$$

where n is the number of sides of the polygon and ∞ is a very large number of the order of the quantum-geometrical diameter of a circle at our scale (QGD doesn't allow infinities).

So, within quantum-geometrical space, the geometrical π is a rational number that corresponds to the ratio of two extremely large integers. In fact, the size of the numerator and denominator are such that the decimal periodicity of their ratio is too large for any current computers to express.

Mathematical operations in quantum-geometry always are carried out from discrete units and can only result in discrete quantities.

In conclusion, the reader will understand that if space is quantum-geometrical, then the mathematics used to describe it and the objects it contains must also be quantum-geometrical. Continuous mathematics, though it can provide approximations of discrete phenomena at larger than fundamental scales, becomes inadequate the closer we get to the fundamental scale.

The Concept of Time

Although time is a concept that has proven useful to study and predict the behaviour of physical systems (not to mention how, on the human level, it has become an essential concept to organize, synchronize and regulate our activities and interactions) it remains just that; a concept.

Time is a relational concept that allows us to compare events with periodic systems; in other words, clocks. But time has no more effect on reality than the clocks that are used to measure it. In fact, when you think of it, clocks don't really measure time. Clocks count the number of recurrences of a particular state. For instance, the number of times the pendulum of a clock will go back to a given initial position following a series of causality linked internal states. So clocks do not measure time, they count recurrent states or events.

If clocks do not measure time, what does?

That answer is nothing can. There has never been a measurement of time and none will ever be possible since time is non-physical. Neither has there been or ever will be a measurement of a physical effect of time on reality. Experiments have shown that rates of atomic clocks are affected by [speed](#) and [gravity](#), but these are [slowing down of clocks](#) and not a slowing of time.

Yet, as useful the concept of time may be, it is not, as generally believed, essential to modeling reality. In fact, taking the concept of time out of our descriptions of reality solves a number of problems.

For instance, mass, momentum, speed and energy are intrinsic properties thus different observers will measure the same mass, speed, momentum and energy regardless of the frame of reference they use.

And if time does not exist, neither does time dilation. Time dilation and the implied assumption of space continuum are essential to explain the constancy of the speed of light in special relativity. But neither is necessary in QGC since the [constancy of the speed of light](#) follows naturally from the discreteness of space.

Finally, if time does not exist, then although the unification of space (a representation of space to be precise) and time (which is a relational concept) into mathematical space-time provides a useful framework in which we can study the evolution of a system, physical space-time makes no sense.

The Quantum-Geometrical Nature of Matter

If space is discrete, then matter, which exists in quantum-geometrical space must also be discrete. Not only must it be discrete, but it must fit the discrete structure of quantum-geometrical space. That is, it should correspond to the amount of matter which can occupy the quantum of space that is the $preon^{(-)}$. We assigned the name $preon^{(+)}$, symbol $p^{(+)}$, to the fundamental particle of matter. QGD assumes that $preons^{(+)}$ is the only fundamental particle of matter, hence all other particles are composite particles made of $preons^{(+)}$.

$Preons^{(+)}$ are fundamental so, to be in agreement with our definition of what constitutes a fundamental particle, they do not decay into other particles or composed of other particles as a consequence they are conserved throughout the entire existence of the universe. This implies that the amount of matter of the universe remains constant and finite throughout its existence.

Also, in the same way that the interactions between two $preon^{(-)}$ is the fundamental unit of n-gravity or g^{-} , the interactions between two $preon^{(+)}$ is the fundamental unit of *p-gravity* or g^{+} . Here however, while n-gravity is a repulsive force acting between $preons^{(-)}$ from which emerges quantum-geometrical space, p-gravity is an attractive force acting between $preons^{(+)}$ ².

In addition to carrying the fundamental force of p-gravity, $preons^{(+)}$ are strictly kinetic particles and as such have momentum. The properties of fundamental particles must evidently also be fundamental, so the momentum of a $preon^{(+)}$ is fundamental, that is, it never changes. Also fundamental is the fundamental velocity of the $preon^{(+)}$ which as we will see must be deduced from its momentum using QGD's definition of velocity we will introduce later and shown to be equal to the speed of light.

$Preon^{(+)} | Preon^{(+)}$ pairs

If $preon^{(-)}$ are the fundamental unit of space, then they must at most hold one fundamental unit of matter. If the $preon^{(-)}$ could hold n $preons^{(+)}$ than then fundamental unit of space with be $\frac{preon^{(-)}}{n}$ or one n^{th} which would be inconsistent with axiom 1. Therefore, there is the *exclusion principle* by which a $preon^{(-)}$ can only host a single $preon^{(+)}$.

² We will show in the section about the formation of particles how p-gravity binds $preons^{(+)}$ into particles and structures.

The $preon^{(+)}$ is strictly kinetic and moves by leaping from $preon^{(-)}$ to $preon^{(-)}$. If it exists, it must occupy space and so transitorily must pair with $preons^{(-)}$ along its path. And since $preons^{(-)}$ and $preons^{(+)}$ are fundamental, that is, they and their intrinsic properties are conserved, $preon^{(-)} | preon^{(+)}$ pairs must interact with each other through both n-gravity and p-gravity.

Propagation

Propagation implies motion; the displacement of matter ($preons^{(+)}$) through quantum-geometric space. A $preon^{(+)}$ a will leap from the $preon^{(-)}$ it is paired with to the next adjacent $preon^{(-)}$ in direction of its momentum vector \vec{P}_a .

$$\text{Two } preons^{(-)} \ p_1^{(-)} \text{ and } p_1^{(-)} \text{ are adjacent if } G(p_1^{(-)}; p_2^{(-)}) = -1 .$$

The preonic leap is the fundamental unit of displacement and determines the fundamental speed of $preons^{(+)}$. We will show that the speed of light and its constancy are direct consequence of the structure of quantum-geometrical space and the speed of $preons^{(+)}$.

Interaction

Interactions through the n-gravity and p-gravity do not require the displacement or exchange of matter. So unlike propagations, interactions are not mediated by quantum-geometric space ($preons^{(-)}$).

We already explained that quantum-geometric space emerges from the interactions between $preons^{(-)}$; the n-gravity field between them. N-gravity does not propagate through quantum-geometric space since it generates it. It follows that n-gravity is instantaneous.

P-gravity, the force acting between $preons^{(+)}$ is similarly instantaneous and, as we will see later, so must be the resultant effects of n-gravity and p-gravity.

Mass, Energy, Momentum of Particles and Structures

We will now derive the properties of mass, energy, momentum and speed from the axiom set of QGD.

Mass

The fundamental units of matter are $preons^{(+)}$. The mass of any particle or structure is an intrinsic property and corresponds to the number of $preons^{(+)}$ that compose it.

We will show that this simple and natural definition of mass is the only one required to describe any physical system.

Also, as an intrinsic property, mass is observer independent (see here for the way by which we can obtain the intrinsic mass of an object).

Energy

The fundamental unit of energy corresponds to the kinetic energy of the $preon^{(+)}$ which is equal to the magnitude of its momentum vector \vec{c} . That is $E = \left\| \vec{P}_{p^{(+)}} \right\| = \left\| \vec{c} \right\| = c$.

Note that we use the symbol c because, as we will show that the fundamental energy of a $preon^{(+)}$ is numerically equal its momentum and to its speed, the latter being equal to the speed of light.

From our definitions of mass and energy, we find that the energy E_a of an object a is equal product its mass m_a (the number of $preons^{(+)}$ it contains) by the fundamental energy of the $preon^{(+)}$. That is:

$$E_a = \sum_{i=1}^{m_a} \left\| \vec{c}_i \right\| = m_a c \quad (2)$$

For a single $preon^{(+)}$ we have $m_{p^{(+)}} = 1$ so $E_{p^{(+)}} = \left\| \vec{c}_i \right\| = c$.

Momentum

The momentum vector of a $preon^{(+)}$ is fundamental. It never changes magnitude, but when bound within a structure $preons^{(+)}$ their follow bounded trajectories. That is, the directions of the component vectors change as they follow trajectories determined by the inner interactions acting between them.

The momentum of a body of a is the magnitude of its momentum vector $\vec{P}_a = \sum_{i=1}^{m_a} \vec{c}_i$, that is:

$$P_a = \left\| \vec{P}_a \right\| = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| \quad (3).$$

But since $\max \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| = \sum_{i=1}^{m_a} \left\| \vec{c}_i \right\| = m_a c$ then $0 \leq \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| \leq m_a c$; the maximum momentum of an body is equal to its energy which occurs in structures when the trajectories of bound $preons^{(+)}$ are parallel.

Velocity

The velocity of a particle or structure follows naturally from QGD's axiom set and corresponds to the ratio of its momentum vector over its mass. That is:

$$\vec{v}_a = \frac{\sum_{i=1}^{m_a} \vec{c}_i}{m_a} \quad (4) .$$

And since both momentum and mass are intrinsic, thus frame independent, so it must be of velocity. We'll call the speed as defined in equation (4) as the *intrinsic speed*.

Therefore, the conventional concept of velocity is not a measure of the intrinsic velocity, but really a measure of distance; specifically, the distance travelled by an object in a given direction between periodic events (the ticks of a clock for example). As for the distance travelled, we understand that it is relative to the frame of reference against which the measurement is made. The velocity given as the ratio the relative distance over time (which basic unit is the number of recurrences of the state of a periodic system), we will call *conventional relative speed* or simply the *relative speed*.

If as per QGD's axioms space is quantum-geometrical, then space is a fixed structure which provides an absolute frame of reference. We may define the absolute distance as the distance as the distance between two positions in quantum-geometrical space (two *preons*⁽⁻⁾) . We will explain later, how to derive the absolute distances between two positions from measurements of relative distances.

We can define the *absolute velocity* \vec{v}_a as the ratio of the absolute distance d and time t is the counted number of recurrences of a chosen state of arbitrarily chosen periodic systems or $\vec{v}_a = \frac{d}{t}$. The absolute velocity is distinct from the intrinsic velocity as they represent entirely different physical properties and moreover properties of distinct objects. The intrinsic velocity is a property of the particle independent of space (although displacement is consequence of the intrinsic velocity). Absolute velocity is not a physical property as such but the measure of the consequential displacement resulting from the intrinsic velocity. The relation between intrinsic velocity (not relative velocity) and absolute velocity $\vec{v}_a \propto \vec{v}_a$ is not one of equivalence but one of proportionality. But though they have different physical meaning, they are numerically equivalent which allows us to use the absolute velocity in QGD equations.

Heat, Temperature and Entropy

From the concepts we have introduced so far, we will now derive the properties of *heat*, *temperature* and *entropy*.

Given a system S having n unbound particles, the heat of the system is equal to $\sum_{i=1}^n P_i$, where

P_i is the magnitude of the momentum vector of the i^{th} particle and its temperature is $\frac{\sum_{i=1}^n P_i}{Vol_S}$

.where Vol_S is the volume of the system measured in $preons^{(-)}$, the fundamental and discrete particle which forms and dimensionalizes quantum-geometrical space. The total energy of the system being equal to $\sum_{i=1}^n m_i c$, it follows that if we define entropy in the classical sense, then the

entropy of S is $\sum_{i=1}^n m_i c - \sum_{i=1}^n P_i$.

Application to Exothermic Reactions within a System

The QGD definitions can be used to describe the changes in heat and temperature resulting from chemical or nuclear reactions. The particles involved are different, as are the reaction mechanisms, and the reactions occur at different scales, but both result in changes in the structure and number of bound particles.

Consider $S_1 \rightarrow S_2$ where S_1 is a dynamic system containing n_1 unbound particles (or structures) some of which reacting with each other, and S_2 the resulting system containing n_2 unbound particles, if $n_2 > n_1$ then $\sum_{i=1}^{n_1} P_i < \sum_{i=1}^{n_2} P_i'$ and the change in heat of the system

$\Delta H = \sum_{i=1}^{n_2} P_i' - \sum_{i=1}^{n_1} P_i$ is positive.

For example, let say the system contains only a particle e^- and a particle e^+ which annihilate to give n photons (γ), then $\Delta H = \sum_{i=1}^n m_{\gamma_i} c - (v_{e^-} m_{e^-} + v_{e^+} m_{e^+})$. Here, the difference in heat depends on the speed of interacting electrons and is at the lowest when electrons achieve the speed of light; in which case $\Delta H = 0$. Note that from the QGD model, when electrons achieve c , internal motion stops, so that component $preons^{(+)}$ move in parallel trajectories.

Also, QGD predicts that electrons accelerated to c become indistinguishable from photons and become electrically neutral. The electrical charge of a particle is caused by internal motion of its component $preon^{(+)}$ which interact with the preonic field (the free $preons^{(+)}$ populating quantum-geometrical space). Since all internal motion stop at speed c , the electron moving at that speed must lose their electric charge.

Also worth noting is that $\sum_{i=1}^n m_{\gamma_i} = m_{e^-} + m_{e^+}$ which implies that $E_{S_1} = E_{S_2}$, that is; mass and energy are conserved. This holds for all closed systems. So though it is believed that a nuclear reaction results in the conversion of mass into energy, according to QGD, it results in the freeing of bound particles which carry with them momentum, hence increase the heat of the system. Aside from the reaction mechanism, the only difference between exothermic chemical and nuclear reactions is in the type of particles that become free. For chemical reactions these particles are molecules, atoms and photons and for nuclear reactions, nuclei and other subatomic particles.

The Velocity of Light and Preons⁺

The intrinsic velocity of a $preon^{(+)}$ is $\vec{v}_{p^{(+)}} = \frac{\sum_{i=1}^{m_{p^{(+)}}} \vec{c}_i}{m_{p^{(+)}}} = \frac{\vec{c}_1}{1} = \vec{c}$ is fundamental. The velocity of light

is a direct consequence of the intrinsic speed of the $preon^{(+)}$ but only the absolute velocity of photons can be measured (it is the two way measurement of the velocity of light). However, the relation between the intrinsic and absolute velocity allows us to substitute the absolute velocity of light in QGD equations for both the intrinsic velocity and momentum of the $preon^{(+)}$ and the intrinsic velocity of photons and neutrinos.

The energy of an object is then the product of the absolute mass by the absolute speed.

Also, we can deduce the absolute speed of an object a by comparing the absolute distance $\overset{d}{\mapsto a}$

it travels to the absolute distance $\overset{d_\gamma}{\mapsto}$ light simultaneously travels. Using the relation $\frac{\overset{\parallel}{\mapsto} v_a \parallel}{\overset{\parallel}{\mapsto} c \parallel} = \frac{\overset{d}{\mapsto a}}{\overset{d_\gamma}{\mapsto}}$

we find that $\overset{\parallel}{\mapsto} v_a \parallel = \frac{\overset{d}{\mapsto a}}{\overset{d_\gamma}{\mapsto}} \overset{\parallel}{\mapsto} c \parallel = \frac{\overset{d}{\mapsto a}}{\overset{d_\gamma}{\mapsto}} c$.

Time Distance Equivalence

As explained earlier, time is a useful concept but it is not physical and introduces a number of problems when it comes to describing reality.

However, time can be advantageously replaced by a physical quantity. For example, we may use instead use the absolute distance a photon simultaneously travels.

Physical Interpretation of the Equal Sign in Equations

$E_a = m_a c$, the equation relating energy and mass appears which is derived naturally from QGD's axiom set appears similar to Einstein $E = mc^2$ (which itself reduces to $E = mc$ when the speed of light is taken as a unit). But there are essential distinctions between the two.

Einstein's equation is understood as an expressing the equivalence between mass and energy. That is, mass and energy are considered to be two forms of the same thing so mass can be converted to energy and vice versa. This interpretation implies that pure energy (photons) and pure mass can exist.

QGD's equation expresses a proportionality relation between distinct physical properties that cannot exist separately. All particles, including photons, are made of $preons^{(+)}$ and as we have seen their mass is simply the amount of matter they contain, that is, the number of $preons^{(+)}$ they are composed from. And since $preons^{(+)}$ have an intrinsic kinetic energy, it follows that the energy of a particle or structure is simply the number of $preons^{(+)}$ times their intrinsic energy or $E_a = m_a c$. The equal sign expresses the proportionality between an intrinsic property of matter and the energy associated with it. So according to QGD, it is a grave mistake to assume that the equal sign expresses physical equivalence.

QGD's $E_a = m_a c$ provides a different interpretation of nuclear reactions but one that is more consistent with observations. While the classical interpretation of Einstein's equation implies that nuclear reactions result in a certain amount of mass being transformed into energy, QGD model suggests is that during a nuclear reaction, mass is not transformed into energy, but rather, bound particles are freed from the structures they were bound into and carry with them their momentum. According to QGD, there is no conversion of mass into energy, but only the release of particles having momentum.

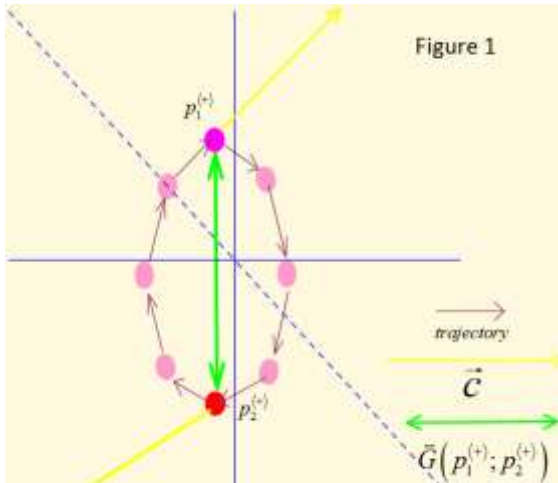


Figure 6

To illustrate this, let's consider the simple particle made of two bound $preons^{(+)}$ as shown in the following figure 6.

Here the particle, which we'll denote a , is composed of two bound $preons^{(+)}$, $p_1^{(+)}$ and $p_2^{(+)}$. The purple arrows represent their trajectories in quantum-geometrical space.

The energy of this particle is

$$E_a = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c = 2c, \text{ and its momentum}$$

is $P_a = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| = \|\vec{c}_1 + \vec{c}_2\| = 0$. This system has zero momentum, hence cannot impart momentum to any other structure or particle.

But if as a result of a nuclear reaction the bound between the component $preons^{(+)}$ of the particle was broken, the energy of this system would remain the same but the momentum of the system would be equal to the sum of the momentum of the now free $preons^{(+)}$. In this simple case, the momentum of the system would be equal to its energy $\left\| \vec{P}_{p_1^{(+)}, p_2^{(+)}} \right\| = \|\vec{c}_1\| + \|\vec{c}_2\| = 2c$. And the momentum that the system can impart is $2c$. The amount of mass and energy of this two $preons^{(+)}$ system does not change as a result of a nuclear reaction. What changed is the momentum of the system which is interpreted the energy of the system and incorrectly attributed to a conversion of mass into energy. This will be discussed in detail in the appropriate sections of this book.

*

Another example in which it is the QGD interpretation of the equal sign is necessary is in special cases where the component $preons^{(+)}$ of a particle or structure move on parallel trajectories.

In such case we find that that $P_a = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| = \sum_{i=1}^{m_a} \|\vec{c}_i\| = E_a$. That is, for such special cases there number of units of momentum found on the left is equal to the number of units of energy we have on the right. But though the number of units are equal, the units are units of different properties and we must always keep in mind that the units on the left are units of momentum while those on the right are units of energy. They may be numerically equal, but they represent two distinct properties.

Lastly, consider the properties of energy, momentum and speed of a single $preon^{(+)}$.

$$E_{p(+)} = \sum_{i=1}^{m_{p(+)}} \|\vec{c}_i\| = \|\vec{c}\| = c \text{ units of energy}$$

$$P_{p(+)} = \left\| \sum_{i=1}^{m_{p(+)}} \vec{c}_i \right\| = \|\vec{c}\| = c \text{ units of momentum}$$

$$v_{p(+)} = \frac{\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|}{m_{p(+)}} = \frac{c}{1} = c \text{ units of speed}$$

Here we have three distinct intrinsic properties which are quantitatively equal but qualitatively different. So though from the equation above we can derive $E_{p(+)} = P_{p(+)} = v_{p(+)} = c$ we have to remember that c is a fundamental quantity of several distinct fundamental properties.

The necessity of the distinction between mathematical and physical interpretations becomes evident since for most particles and structures $E_{p(+)} \neq P_{p(+)} \neq v_{p(+)}$.

The physical and mathematical interpretations of the relations between physical properties can differ significantly and ignoring such differences leads to incorrect assumptions about nature. For instance, in the section on optics, we will show that the quotient of a Euclidean division of the momentum of a photon over the mass of a particle corresponds to the absorbed part of the photon while the remainder of the operation is the reflected part. The physical interpretation of the mathematical must be derived from the theory's axioms.

The Relation between Objects and Scales

A group of $preons^{(+)}$ maybe treated as a single object a in regards to a given interaction if the effects of the interaction on the object can be fully described in terms of the object's dynamic

properties such as its mass m_a , its momentum $\sum_{i=1}^{m_a} \vec{c}_i$ or its velocity $\vec{v}_a = \frac{\sum_{i=1}^{m_a} \vec{c}_i}{m_a}$, etc.

A physical scale maybe understood as a group objects which can be described as above under a given interaction.

Forces, Interactions and Laws of Motion

The dynamics of a particle or structure is entirely described by its momentum vector. The momentum vector can be affected by forces, which imply no exchange of particles. The momentum vector of a particle or structure can also be affected by interactions during which two or more particle of structures will exchange lower order particles or structures. These are non-gravitational interactions which result in momentum transfer or momentum exchanges.

We will show how all effects in nature result from one or a combination of these two types of interactions.

Gravitational Interactions and Momentum

Following QGD' axiom set, gravity is not a force but the combined effect of n-gravity and p-gravity. The gravity effect between two objects a and b is:

$\vec{G}(a;b) = \vec{G}^+(a;b) + \vec{G}^-(a;b)$ where $\vec{G}^+(a;b)$ is the p-gravity component of gravity and $\vec{G}^-(a;b)$ the n-gravity component.

To obtain $\vec{G}^-(a;b)$ we count the number of n-gravity interactions that exist between every $preon^{(+)}$ of a and every $preons^{(-)}$ of b and with all $preons^{(-)}$ in between. Using the simple combinatory formula, we find that the magnitude of the n-gravitational interaction is

$$\vec{G}^-(a;b) = m_a m_b \frac{d^2 + d}{2} \vec{g}^-$$

where d is the preonic distance between a and b given in $preons^{(-)}$ and \vec{g}^- the n-gravity unit vector.

$\vec{G}^+(a;b)$ is the number of p-gravity interactions between every $preon^{(+)}$ of a and every $preons^{(+)}$ b which is simply $\vec{G}^+(a;b) = m_a m_b \vec{g}^+$.

Now, from observation we know that $\|\vec{g}^+\| \gg \|\vec{g}^-\|$, that is $\|\vec{g}^+\| = k \|\vec{g}^-\|$ so that if we use $\vec{g}^- = -\hat{u}$ as base unit, where \hat{u} is the unit vector along the $[a, b]$ axis, we get:

$$\vec{G}(a;b) = \left(m_a m_b k - m_a m_b \frac{d^2 + d}{2} \right) \hat{u} \text{ which we understand is attractive when } \vec{G}(a;b) > 0 \text{ and}$$

repulsive when $\vec{G}(a;b) < 0$ and neutral for $\vec{G}(a;b) = 0$.

Gravitational Dynamics

From our definition of momentum, we understand that a variation in gravitational interaction between two objects a and b translates into variations of their momentums. We have

$\Delta \vec{P}_a = \Delta \vec{P}_b = \Delta \vec{G}(a;b) = \Delta \vec{G}^+(a;b) + \Delta \vec{G}^-(a;b)$. Therefore, the gravitational accelerations of a and b are respectively $\Delta \vec{v}_a = \frac{\Delta \vec{G}(a;b)}{m_a}$ and $\Delta \vec{v}_b = \frac{\Delta \vec{G}(a;b)}{m_b}$.

Also, since $\Delta \vec{G}^+(a;b) = \vec{0}$ then

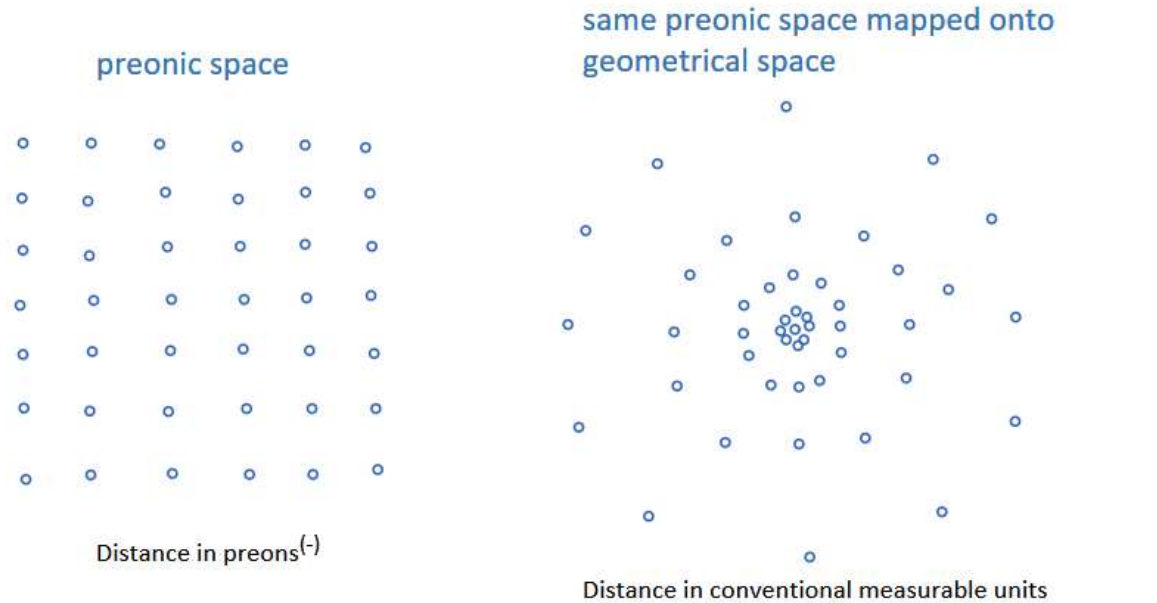
$$\Delta \vec{G}(a;b) = \Delta \vec{G}^-(a;b) \quad (1)$$

And

$$\Delta \vec{P}_a = \Delta \vec{P}_b = \Delta \vec{G}^-(a;b) \quad (2)$$

Derivation of Newton's Law of Gravity

In order to derive Newton's law of gravity from our minimal axiom set we must keep in mind that equation (1) describes gravity in preonic space while Newton's equation describes the effect of gravity in geometrical space (space as we observe it). Therefore, we must map preonic space, which is a regular grid, onto geometrical space.



Blue circles represent reference *preons*⁽⁻⁾ of a region of preonic space with a massive object at its center.

This requires us to take into account the preonic density. The concentration of matter in a body, which is a concentration of $preons^{(+)}$, decreases the n-gravity interaction with surrounding space and in accordance to equation (1) results in spatial density following the inverse square law. As a consequence, $d \propto dens_{preons^{(-)}} \propto \frac{1}{r^2}$ where d is the preonic distance and r is the geometrical distance from the center of a body. Substituting in equation (2) we get:

$$\Delta \tilde{G}^-(a;b) \propto m_a m_b \frac{1}{r^2} \hat{u} \quad (3)$$

which we recognize as Newton's law of gravity.

The reader may note from above that we may derive the geodesics of general relativity from the relation between preonic and geometrical space and have provided a mechanism for the curvature of space, which according to our model is a variation in preonic density resulting from the interaction between matter and preonic space.

One of the most interesting consequences of the above is that the first composite particles and structures would cause anisotropies in preonic space which in turn would have played a major role in the formation of increasingly more massive particles and material structures. Matter increases the preonic density, which in turn allow for higher geometrical density of matter. The ratio of p-gravity over n-gravity increases in a region containing matter, increases the preonic density, which concentrates matter, which increases preonic density. This cycle creates conditions favorable to the formation of increasingly more massive particles and structures.

The Fundamental Momentum and Gravity

That the momentum of the $preon^{(+)}$ is fundamental is a postulate of QGD. It is equal to $\|\vec{P}_{p^{(+)}}\| = \|\vec{c}\| = c$. In fact, of all properties of the $preon^{(+)}$, only its direction is variable. And the only thing that affects it is gravity.

The direction of a $preon^{(+)}$ is determined by the resultant of the gravitational interactions acting on it, which interactions are with free $preons^{(+)}$, particles or structures and if the $preon^{(+)}$ is bound, with the $preons^{(+)}$ that it is bound to.

A change in direction of a $preon^{(+)}$ is proportional to the change in the resultant of the forces acting on it. That is:

$\vec{P}_{p^{(+)}_{s_2}} = \vec{P}_{p^{(+)}_{s_1}} \vec{+} \Delta_{s_1 \rightarrow s_2} \boxed{\vec{G}}$ where $\Delta_{s_1 \rightarrow s_2} \boxed{\vec{G}} = \left(\sum_{j=1}^{m_a} \Delta_{s_1 \rightarrow s_2} \vec{G}(p_i^{(+)}; p_j^{(+)}) + \sum_{k=1}^n \Delta_{s_1 \rightarrow s_2} \vec{G}(p_i^{(+)}; a_k) \right)$ is the

resultant of the forces acting on the *preon*⁽⁺⁾ and $\vec{+}$ is the directional vector sum which we

define as
$$\vec{P}_{p^{(+)}_{s_1}} \vec{+} \Delta_{s_1 \rightarrow s_2} \boxed{\vec{G}} = \frac{\vec{P}_{p^{(+)}_{s_1}} + \Delta_{s_1 \rightarrow s_2} \boxed{\vec{G}}}{\left\| \vec{P}_{p^{(+)}_{s_1}} + \Delta_{s_1 \rightarrow s_2} \boxed{\vec{G}} \right\|} c = \vec{c}_{s_2}.$$

The directional vector sum describes the conservation of the momentum of the *preons*⁽⁺⁾. The result of the directional is the normalized vector sum of the momentum vector of the *preon*⁽⁺⁾ and the variations in gravity vector $\Delta \boxed{\vec{G}}$ between states s_1 and s_2 .

Newton's first law of motion is implied here since for $\Delta \boxed{\vec{G}} = 0$ we have $\vec{P}_{p^{(+)}_{s+1}} = \vec{P}_{p^{(+)}_s}$.

We will see how Newtonian gravity emerges from gravitational interactions at the fundamental scale.

Gravity between Particles and Structures

Astrophysical observations which we shall discuss later suggest that $k \gg 10^{100}$, so that at short distances, the number of n-gravitational interactions being very low and the magnitude of the force being over a hundred orders of magnitude weaker than p-gravity.

$$\vec{G}(a; b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right)$$

The n-gravitational component of QGD equation for gravity is insignificant compared to the p-gravitational component. Gravity at short scales being over a hundred orders of magnitude stronger than at that at macroscopic scales, it is strong enough to bind *preons*⁽⁺⁾ into composite particles and composite particles into larger structures.

Bound *preons*⁽⁺⁾ form particles and structures which then behave as one body which dynamic

property is described by the momentum vector $\vec{P}_a = \sum_{i=1}^{m_a} \vec{c}_i$ which magnitude is its momentum.

That is $P_a = \left\| \vec{P}_a \right\| = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$. Because of that, the dynamics of particles and structures can be

described simply as the evolution of their momentum vector \vec{P}_a from state to state.

Particles and structures are in constant gravitational interactions with all particles and structures in the entire universe. The direction of the momentum vector of a particle or structure at any position is the resultant of its intrinsic momentum and extrinsic interactions. Hence, if the structure of a particle or structure and its interactions remain constant, so will its momentum vector. Changes in momentum are due to variations in the magnitude and direction of the gravitational interaction, hence due to variations in their positions.

For simplicity, we will start by describing the dynamics of a system consisting of two gravitationally interacting bodies.

Consider bodies a and b in state s_1 which interact gravitationally in accordance to the equation

$$\vec{G}(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right).$$

Change in the momentum vector of the bodies from s_1 to the

next causally related state s_2 is $\Delta_{s_1 \rightarrow s_2} \vec{P}_a = \Delta_{s_1 \rightarrow s_2} \vec{G} = \vec{G}(a;b) - \vec{G}(a;b)_{s_1}$ so that

$$\vec{P}_a = \vec{P}_a + \Delta_{s_1 \rightarrow s_2} \vec{G}(a;b) \phi_a \text{ and } \Delta_{s_1 \rightarrow s_2} \vec{P}_b = \Delta_{s_1 \rightarrow s_2} \vec{G} = \vec{G}(a;b) - \vec{G}(a;b)_{s_1} \text{ so that } \vec{P}_b = \vec{P}_b + \Delta_{s_1 \rightarrow s_2} \vec{G}(a;b) \phi_b$$

where s_2 is a successive state of our two body system.

Here $\phi_x = \left\lceil \frac{c - v_x}{c} \right\rceil$ preserves the fundamental limit of the momentum of a particle or structure

which we have shown cannot exceed its energy; that is: $\left\| \sum_{i=1}^{m_x} \vec{c}_i \right\| \leq \sum_{i=1}^{m_x} \|\vec{c}_i\|$. The bracket is the

ceiling function so that for $c < v_x$ we have $\left\lceil \frac{c - v_x}{c} \right\rceil = 1$ and $\Delta_{s_1 \rightarrow s_2} \vec{P}_x = \Delta_{s_1 \rightarrow s_2} \vec{G}(a;b)$ but for

$v_x = c$ we have $\left\lceil \frac{c - v_x}{c} \right\rceil = 0$ and $\Delta_{s_1 \rightarrow s_2} \vec{P}_x = 0$. And since the momentum of a particle or structure

$$\text{cannot exceed its energy, its maximum speed is } \max v_x = \frac{\sum_{i=1}^{m_x} \|\vec{c}_i\|}{m_x} = \frac{m_x c}{m_x} = c.$$

Note that for descriptions of dynamics system at speed below the speed of light, will simply

write $\vec{P}_a = \vec{P}_a + \Delta_{s_1 \rightarrow s_2} \vec{G}(a;b) \phi_a$ and $\vec{P}_b = \vec{P}_b + \Delta_{s_1 \rightarrow s_2} \vec{G}(a;b) \phi_b$ with the understanding that ϕ_x is implicit and equal to 1.

Note: It is important remember that QGD describes gravity as the resulting effect of two distinct forces, p-gravity (attractive) and n-gravity (repulsive). The p-gravity being a function of mass only and n-gravity being a function of mass and distance, the p-gravity and n-gravity components of the equation must always be differentiated separately then added to calculate variations in gravity.

Derivation of the Weak Equivalence Principle

The weak equivalence principle or universality of free fall is easily derived from QGD's equation for gravity $G(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right)$ where m_a and m_b are respectively the masses of a and b and d the distance, all in natural fundamental units.

According to QGD, the change in momentum due to gravity following the change in positions between two successive states s_1 and s_2 is equal to the gravity differential between the two positions $\Delta G(a;b)$. That is: $\left\| \Delta \vec{P}_a \right\|_{s_1 \rightarrow s_2} = \left\| \Delta \vec{G}(a;b) \right\|_{s_1 \rightarrow s_2}$.

QGD defines speed of a body as $v_a = \frac{\left\| \vec{P}_a \right\|}{m_a}$ and the acceleration of a body is $\Delta v_a = \frac{\left\| \Delta \vec{P}_a \right\|}{m_a}$. Since $\left\| \Delta \vec{P}_b \right\| = \Delta G(a;b)$, the acceleration of an object a due to the gravitational interacting between a and b is $\Delta v_a = \frac{\left\| \Delta \vec{P}_a \right\|}{m_a} = \frac{\left\| \Delta G(a;b) \right\|}{m_a}$

Since

$$\Delta G(a;b) = m_a m_b \left(k - \frac{d_1^2 + d_1}{2} \right) - m_a m_b \left(k - \frac{d_2^2 + d_2}{2} \right) = m_a m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right)$$

then

$$\Delta v_b = \frac{1}{m_a} m_a m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right) = m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right).$$

Therefore, gravitational acceleration of a body a relative a second body b is independent of the mass of the first and dependent on the mass of the second. Conversely, the gravitational acceleration of an object b relative to a is given by $\Delta v_b = m_a \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right)$ is independent of m_b . So, regardless of their mass m_a , all bodies a will be accelerated relative to a given body b at the same rate.

We have shown that the weak equivalence principle is a direct consequence of QGD's equation for gravity which itself is derived from QGD's axiom set.

According to QGD, the momentum vector of object is an intrinsic property given by $\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$ where the mass, m_a , is the number of bounded $preons^{(+)}$ of a and each \vec{c}_i correspond to the

momentum vector of a bound $preon^{(+)}$. The speed of object is given by $\frac{\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|}{m_a}$.

Gravity affects the resultant trajectories of the component $preons^{(+)}$, which changes the momentum. The change in speed is a consequence of the change in momentum and not the reverse.

Given two object a and b both at the same distance from a massive structure, it is impossible to distinguish between them based on their respective acceleration, which makes acceleration the wrong property to measure if one wants to compare the effect of gravity on particles or structures.

Variations in the gravitational interaction affect directly and instantaneously the momentum of the interacting bodies. It is the variations in momentum that determine the variations in speed and not the reverse.

Note: Unlike classical or general relativity gravity, QGD attractive gravity does not have an infinite range. QGD's equation for gravity predicts that attractive gravity is dominant for $d < d_\Lambda$ and decreases with distance until $d = d_\Lambda$ at which distance attractive and repulsive components of gravity cancel each other and gravity becomes null. For $d > d_\Lambda$, the repulsive component of gravity becomes dominant, and gravity becomes repulsive and increases with distance.

So, a body b moving away from a body a will be gravitationally decelerated until it reaches a distance d_Λ , beyond which it will be accelerated from that distance on. Only an object with sufficient momentum can escape attractive gravity from a second object. If a and b are gravitationally interacting bodies, $\vec{P}_a > \Delta_{d \rightarrow d_\Lambda} \vec{G}(a; b)$, where d is the initial distance from which we make the calculation.

Comparison between the Newtonian and QGD Gravitational Accelerations

From $\Delta v_b = m_a \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right)$ we have

$$m_b \Delta v_b = m_a m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right) = \Delta G(a; b) \text{ which is equivalent to Newton's}$$

second law of motion relating force, mass and acceleration $F = m \Delta v_a$ where $F = \Delta G(a; b)$.

The equations are very similar and it would be tempting to equate Newton's second law and its QGD equation, but this cannot be done directly.

Newtonian gravity varies with distance and is time independent. However Newton's second law of motion when applied to gravity ignores the distance dependency but treats the force as if it were constant. And most importantly, despite the fact that Newtonian gravity is instantaneous (as must be its effects) Newtonian mechanics introduces a time dependency on the effect of gravitational acceleration. The introduction of the time dependency of the gravitational acceleration is not in agreement with Newton's law of gravity. And while the time dependency approximates its dependency on distance (since $\Delta d \propto \Delta t$ and $\vec{v}_b \propto \vec{v}_b$ where \vec{v}_b is the classically defined speed) it introduces delays on the action which according to Newton's law of gravity does not exist.

Newton's second law of motion applied to gravity gives $\Delta \vec{v}_b = \frac{\vec{G}(a; b) \Delta t}{m_b}$ where $\vec{G}(a; b)$

represents the Newtonian force of gravity. Since the QGD equation is $\Delta \vec{v}_b = \frac{\Delta \vec{G}(a; b)}{m_b}$, it

follows that $\vec{G}(a; b) \Delta t \approx \Delta \vec{G}(a; b)$. But the assumed time dependency of the effect introduces a delay in the effect of gravity on the momentum of a body while it should be instantaneous. So

for Newtonian mechanics we have $\frac{\Delta \vec{v}_b}{\Delta t} = \frac{\vec{G}(a; b)}{m_b}$ while in QGD $\Delta \vec{v}_b = \frac{\Delta \vec{P}_b}{m_b} = \frac{\Delta \vec{G}(a; b)}{m_b}$. So

the Newton's law of motion introduces a delay of $\Delta t = \frac{m_b \Delta \vec{v}_b}{\vec{G}(a; b)}$.

Such delays of the effect of gravitational acceleration are very small since the distance between two positions in quantum-geometrical space is fundamental, and it would be difficult if not impossible to detect over short variations in distance, especially if there are no changes in direction of the gravitationally accelerated body. But over an astronomical number of changes in direction, such as experienced by a planet orbiting the sun, the predicted delays would add up to observable differences with the observed motion of the planet. As we will discuss in detail

[later in this book](#) by removing the time dependency in accordance to QGD, Newtonian gravity correctly predicts the precession of the perihelion of Mercury.

Therefore, the discrepancy between Newtonian mechanics' prediction of the motion of Mercury and observation is due to the time dependency introduced when using Newton's second law of motion; incorrectly making the effect of an instantaneous force dependent on time.

It is also interesting to note that the application of general relativity to the motion of Mercury (or other bodies) does the exact opposite since the effect of a change in position of a body in a gravitational field instantly changes its direction because it instantly follows the predicted geodesics. This may explain why general relativity correctly predicts the precession of the perihelion of Mercury.

Non-Gravitational Interactions and Momentum

The momentum of a particle or structure may also change as the result of absorption of particles.

For example, if a absorbs a photon λ then $\vec{P}_a = \vec{P}_a + \vec{P}_\lambda$. Similarly, if it emits a photon then

$\vec{P}_a = \vec{P}_a - \vec{P}_\lambda$. Note that depending of the relative direction of a and the absorbed photon, \vec{P}_a may be greater or smaller than \vec{P}_a .

The mass of particle or structure increases or is reduced by an amount that is equal to the mass of the absorbed or emitted photon (or other particle).

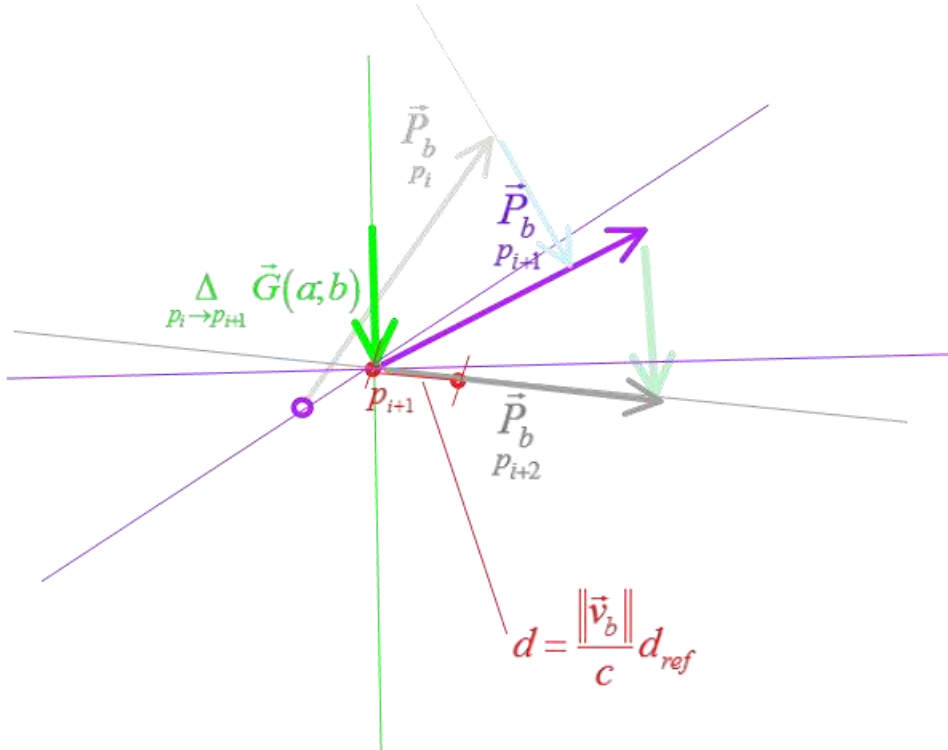
Since $v_a = \frac{\vec{P}_a + \vec{P}_\lambda}{m_a}$ and $\Delta v_a \simeq \frac{\vec{P}_\lambda}{m_a}$ the acceleration is inversely proportional to the mass of the

object that is accelerated. Gravitational acceleration being independent of its mass, there is no equivalence between gravity and non-gravitational acceleration as suggested by Einstein's famous thought experiment. We will show that it is possible to distinguish the effect of gravity from constant acceleration because their effect on mass, momentum and energy are different for different bodies.

Application to Celestial Mechanics

If gravity is instantaneous, then its effects are also instantaneous. It follows that a body is always at equilibrium with the gravitational forces acting on it. We will call this the *principle of equilibrium*.

As we will see, the principle of equilibrium governs all dynamics of all gravitationally interacting system, thus will be central to QGD's description of the motion of gravitationally interacting celestial objects.

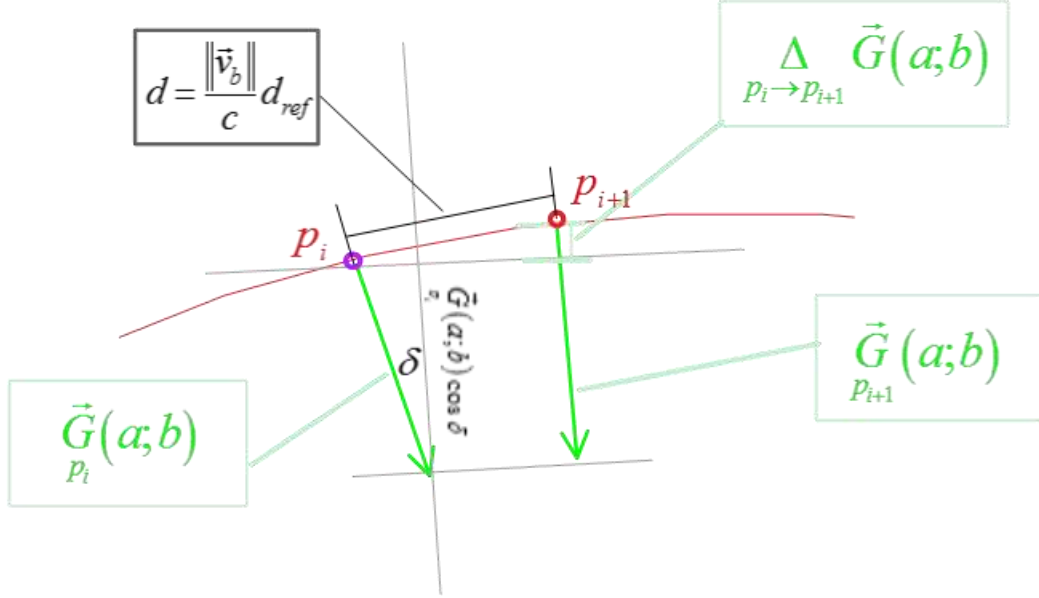


Therefore, the change in momentum of a body from one position to the next corresponds to the instantaneous change in net magnitude of the forces acting on it between the two positions. We will now see how this applies to describe the motion of a planet orbiting a star.

From the principle of equilibrium it follows that at a position p_i the momentum of a body b gravitationally interacting with a body a is given by $\vec{P}_b = \vec{P}_b + \Delta \vec{G}(a;b)$ where p_{i-1} is the preceding position of b and $\Delta \vec{G}(a;b) = \frac{\|\vec{G}(a;b) - \vec{G}(a;b)\| \cos \delta}{\|\vec{G}(a;b)\|} \vec{G}(a;b)$ with δ

being the angle between $\vec{G}(a;b)$ and $\vec{G}(a;b)$. Orbiting bodies are a special case of which for

with $\vec{P}_b \sin \theta < - \Delta_{p_{i-1} \rightarrow p_i} \vec{G}(a; b)$ where θ is the angle between \vec{P}_b and the tangent of the orbit at p_i .



For any position p_i , the following position is found along the direction of \vec{P}_b and the distance between p_i and p_{i+1} is $d = \frac{\|\vec{v}_b\|}{c} d_{ref}$, d_{ref} is a reference distance chosen so that $d \geq 1$ (smaller d_{ref} gives more accurate the description).

From the above equations we can deduce that the shape of the orbit of body b around a fixed body a would be nearly circular since $\Delta_{p_{x-1} \rightarrow p_x} \vec{G}(a; b) \approx \Delta_{p_{y-1} \rightarrow p_y} \vec{G}(a; b)$, but bodies are in space are in motion so since $\Delta_{p_{i-1} \rightarrow p_i} \vec{G}(a; b)$ is greater when the bodies move towards each other than when moving in opposite direction that the shape of the orbit around a moving body will be elliptical.

Also, since $\vec{v}_b = \frac{\vec{P}_b}{m_b}$ then $d = \frac{\|\vec{v}_b\|}{c} d_{ref} = \frac{\|\vec{P}_b\|}{m_b c} d_{ref} = \frac{\|\vec{P}_b\|}{E_b} d_{ref}$ which gives an interesting relation between the momentum and energy of b and the distance travelled. So for preons⁽⁺⁾, photons and neutrinos, since $\|\vec{P}_b\| = E_b$, $d = d_{ref}$.

An Important Distinction between QGD and other Gravity Theories

There is an important distinction between QGD's description of gravity or other theories of gravity in that it is not the magnitude of the gravitational interaction that causes gravitational acceleration but instantaneous variations in the gravitational vectors resulting from discrete changes in positions.

N-Body Gravitationally Interactions

For a system consisting of n gravitationally interacting bodies,

$$\Delta \vec{P}_{a_{i,s+1}} = \Delta \vec{G}_{j=1}^n(a_{i,s}; a_{j,s+1})$$

where a_i and a_j are gravitationally interacting astrophysical bodies of the system, $j \neq i$ and

$$\Delta \vec{G}_{j=1}^n(a_{i|s+1}; a_{j|s+1}) = \Delta \vec{G}_{s+1}(a_{i|s+1}; a_{1|s+1}) + \dots + \Delta \vec{G}_{s+1}(a_{i|s+1}; a_{n|s+1}) \text{ where}$$

$\Delta \vec{G}_{s+1}(a_{i|s+1}; a_{j|s+1}) = \vec{G}(a_{i|s+1}; a_{j|s+1}) - \vec{G}(a_{i|s}; a_{j|s})$ and s and $s+1$ are successive states of the system (a state being understood as the momentum vectors of the bodies of a system at given co-existing positions of the bodies) and $a_{i|s+x}$ is the body a_i and its position when at the state $s+x$. The position itself is denoted $\mathcal{E}_{a_i|s+x}$.

In order to plot the evolution in space of such a system, we must choose one of the bodies as a reference so that the motions of the others will be calculated relative to it. A reference distance travelled by our reference body is chosen, d_{ref} , which can be as small as the fundamental unit of distance (the leap between two *preons*⁽⁻⁾ or *preonic leap*) but minimally small enough as to accurately follow the changes in the momentum vectors resulting from changes in position and gravitational interactions between the bodies.

So given an initial state s , the state $s+1$ corresponds to the state described by the positions and momentum vectors of the bodies of the system after the reference body travels a distance of d_{ref} . For simplicity, we will assign a_1 to the reference body.

$$s+1 = \left\{ \begin{array}{l|l} \vec{P}_{a_{1|s+1}} = \vec{P}_{a_{1|s}} + \Delta \vec{G}_{j=1}^n(a_{1|s}; a_{j|s+1}) & \mathcal{E}_{a_1|s+1} \\ \dots & \dots \\ \vec{P}_{a_{n|s+1}} = \vec{P}_{a_{n|s}} + \Delta \vec{G}_{j=1}^n(a_{n|s}; a_{j|s+1}) & \mathcal{E}_{a_n|s+1} \end{array} \right\} \quad (5)$$

Using the state matrix, the evolution of a system from one state to the next is obtained by simultaneously calculating the change in the momentum vectors from the variation in the gravitational interaction between bodies resulting from their change in position. Changes in the momentum vectors have are as explained earlier. Changes in position are given by

$$\mathcal{E}_{a_i|s+1} = \mathcal{E}_{a_i|s} + \frac{v_{a_i}}{v_{a_1}} \frac{d_{ref}}{\|\vec{P}_{a_i}\|} \vec{P}_{a_i}. \text{ The distance travelled by } a_i \text{ from } s \text{ to } s+1 \text{ is } \frac{v_{a_i}}{v_{a_1}} d_{ref} \text{ (for } j=1, \text{$$

the distance becomes simply d_{ref}) and distance between two bodies of the system at state $s+x$ is $d_{a_i;a_j|s+x} = \mathcal{E}_{a_i|s+x} - \mathcal{E}_{a_j|s+x}$. It is interesting to note here that that for $i=j$, then $d_{a_i;a_j|s+x} = 0$, so that

$$\begin{aligned} \Delta \vec{G}_{s+1}(a_{i|s+1}; a_{j|s+1}) &= \vec{G}(a_{i|s+1}; a_{i|s+1}) - \vec{G}(a_{i|s}; a_{i|s}) \\ &= m_a m_a \left(k - \frac{d^2_{a_i;a_i|s+1} - d_{a_i;a_i|s+1}}{2} \right) - m_a m_a \left(k - \frac{d^2_{a_i;a_i|s} - d_{a_i;a_i|s}}{2} \right), \\ &= m_a m_a k - m_a m_a k \\ &= 0 \end{aligned}$$

the variation in the gravitational interaction between a body with itself is equal to zero, which implies that its momentum vector will remain unchanged unless $n > 1$ and $\Delta \vec{G}_{j=1}^n(a_{n|s}; a_{j|s+1}) \neq 0$. This is the QGD explanation of the first law of motion.

Transfer and Conservation of Momentum

Also, a consequence of the discreteness of space is that the momentum of an object a can only change by a multiple of its mass (each component $preon^{(+)}$ must overcome the effect of n-gravity which are discrete units). All changes in momentum obeys must obey the law $\Delta \|\vec{P}_a\| = xm_a$.

Changes in momentum due to variation in gravity are proportional to the mass of the body subjected to it so that $\|\Delta \vec{G}(a;b)\| = xm_a$ $\|\Delta \vec{P}_a\| = xm_a$ law since.

Gravity and variation in gravity between two objects are multiples of their masses of the object, but this is not the case for non-gravitational interactions.

For instance, the momentum of a photon will only in special cases be a multiple of the mass of the object it interacts with.

For instance, for an electron e^- and a photon γ . Then we have the three possibilities:

1. $\|\vec{P}_\gamma\| < xm_{e^-}$ or
2. $\|\vec{P}_\gamma\| = xm_{e^-}$ or
3. $\|\vec{P}_\gamma\| \geq xm_{e^-}$ where $x \in N^+$

In case 1, the momentum of the photon is below the minimum allowed change in momentum of the electron. The photon cannot be absorbed (become bounded) and so will be reflected or refracted depending on its trajectory relative to the electron.

In case 2, the photon will be absorbed and $\|\Delta \vec{P}_\gamma\| = xm_{e^-}$. In this case, all its $preons^{(+)}$

will become part of the electron's structure, the electron's mass will increase by m_γ its momentum by $\|\vec{P}_\lambda\|$.

In case 3, though the photon's momentum is greater than the minimum allowed change in momentum for a , absorption is not possible as it would imply a fractional change in the momentum of e^- and thus is forbidden (a fractional change in momentum would imply that material structure could move between $preons^{(-)}$ which is not possible since there is no space which can hold them).

The electron can absorb the higher momentum (or energy since for photons $\|\vec{P}_\gamma\| = E_\gamma$) but to respect the $\Delta\|\vec{P}_a\| = \chi m_a$ law it must simultaneously emit a photon γ' that will carry the excess momentum.

The emitted photon γ' is such that $\|\vec{P}_{\gamma'}\| = \|\vec{P}_\gamma\| - \left\lfloor \frac{\|\vec{P}_\gamma\|}{m_{e^-}} \right\rfloor m_{e^-}$.

This, we shall see later, describes why atomic electrons can only absorb photons have specific momentum and thus explain the emission and adsorption lines of elements.

Momentum Conservation and Impact Dynamics

A postulate of quantum-geometry dynamics is that space is fundamentally discrete (quantum-geometrical, in QGD terms). If as QGD suggests the discreteness of space exists at a scale that is orders of magnitude smaller than the [Planck scale](#) then the fundamental structure of space (and matter) lies way beyond the limits of the observable.

That said, the discreteness of space and matter, as described by QGD, carries unique consequences at observable scales. In fact, the laws that govern the dynamics of large systems can be derived from the laws governing space and matter at its most fundamental.

We will now re-examine observations which, when interpreted by QGD, supports its prediction of the quantum-geometrical structure of space, more specifically, we will show the law of conservation of momentum at the fundamental scale explain the conservation of momentum at larger scales.

The Physics of Collision and Conservation of Momentum

Three laws govern the physics of collision:

1. So, two objects cannot occupy the same space at the same time (a consequence of the preonic exclusion principle).
2. The momentum of particles is conserved in non-gravitational interactions.
3. Changes in the momentum of an object is a multiple of its mass or $\|\Delta\vec{P}_a\| = \chi m_a$.

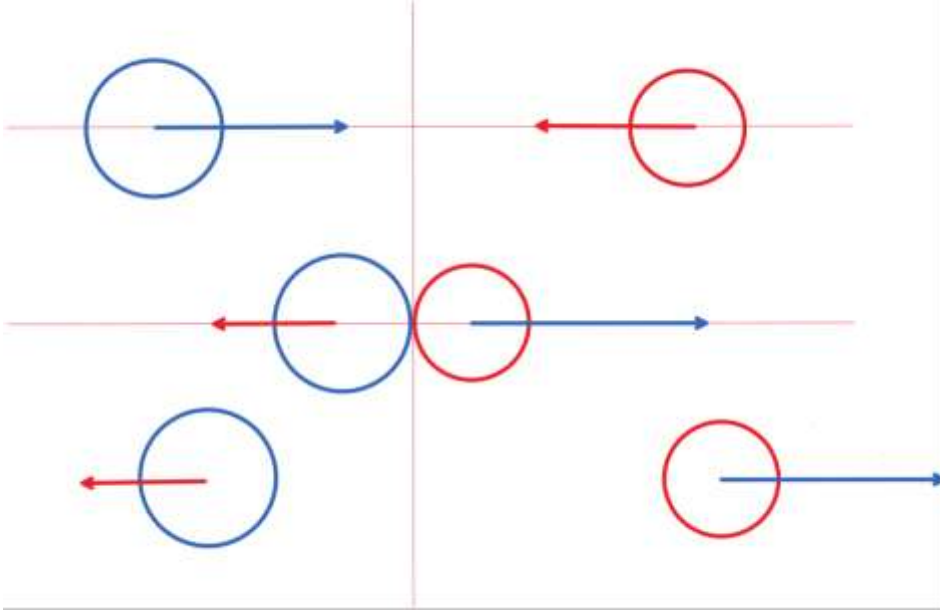
Case 1

For simplicity, let a and b be two rigid spheres of same volume with momentum \vec{P}_a and \vec{P}_b , which are set on a direct collision course as in the figure below.

When the spheres reach the position of impact, the first law applies. Neither sphere can occupy that position. So, the spheres cannot move beyond the point of impact or, to be precise, the intersection of the volumes of the spheres along the line of impact, which is the line that passes through the centers of the spheres at impact.

To satisfy the second law, the spheres a and b in the simple example below must each emit photons whose momentums will be exactly those of a and b respectively. That is:

$\sum_{i=1}^{n_a} m_{\gamma_i} c = \|\vec{P}_a\|$ and $\sum_{j=1}^{n_b} m_{\gamma_j} c = \|\vec{P}_b\|$ where n_a and n_b are respectively the numbers of photons emitted at impact by a and b .



The photons emitted by a will be absorbed by b , imparting it their momentum and the photons emitted by b will impart their momentum to a so that after impact $\vec{P}'_a = \sum_{i=1}^{n_b} m_{\gamma_i} c = \vec{P}_b$ and

$\vec{P}'_b = \sum_{i=1}^{n_a} m_{\gamma_i} c = \vec{P}_a$ where \vec{P}'_a and \vec{P}'_b are respectively the momentums of a and b after impact.

As a result of the impact, the spheres will move in opposite direction at speed $v_a = \frac{\|\vec{P}_b\|}{m_a}$ and

$$v_b = \frac{\|\vec{P}_a\|}{m_b}.$$

Case 2

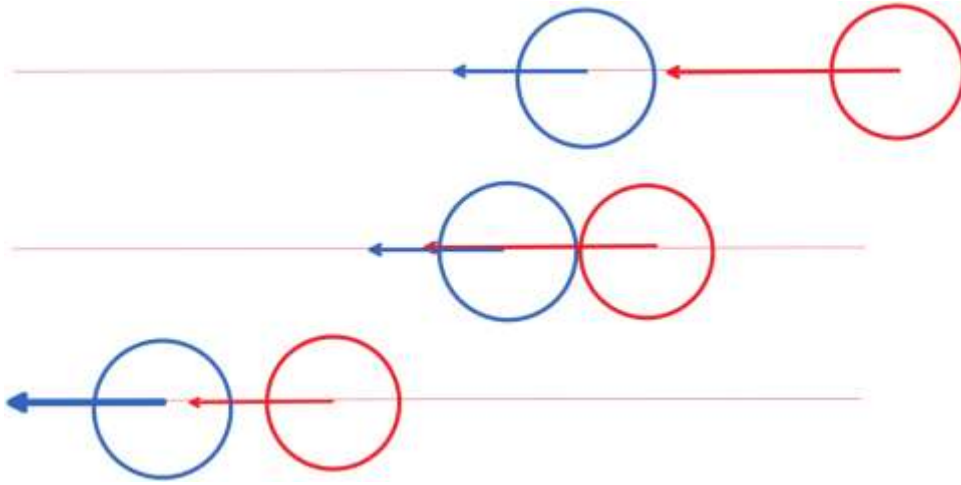
Consider two spheres of equal mass moving in the same direction as in the figure below.

Here, at the point of impact, the forbidden component of the momentum of a in direction of b is given by $(v_a - v_b)m_a$, but the component momentum of b in direction of a is equal to zero.

³ Note that for simplicity, we ignored here the changes in the masses of the spheres due to emission and absorption of photons. These variations in mass will be taken into account when significant.

That is $\sum_{i=1}^{n_a} m_{\gamma_i} c = (v_a - v_b) m_a$ and $\sum_{j=1}^{n_b} m_{\gamma_j} c = 0$, hence after impact the momentums of a and b will be

$$\begin{aligned} \|\vec{P}'_a\| &= \|\vec{P}_a\| - (v_a - v_b) m_a \\ &= \|\vec{P}_a\| - \left(\frac{\|\vec{P}_a\|}{m_a} - v_b \right) m_a \\ &= m_a v_b \end{aligned}$$

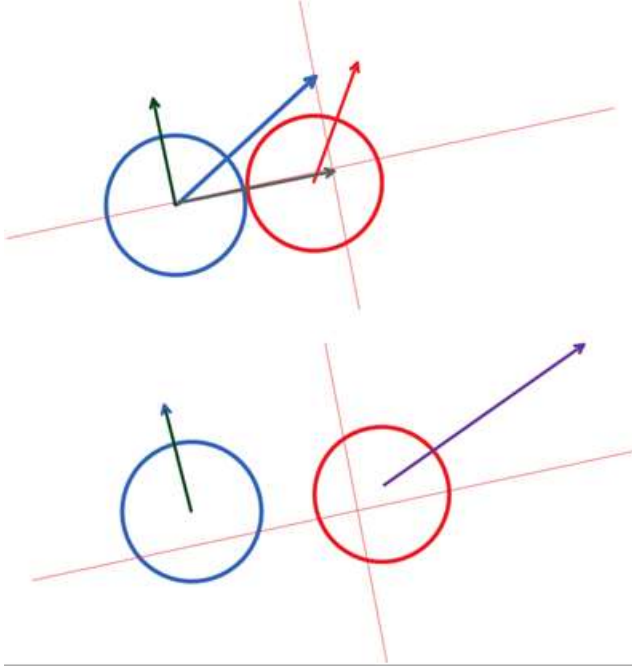


We can see that Newton's third law of motion is a direct consequence of the three laws governing collision physics but that it is not due, as Newton's third law implies, to the second body exerting a force equal magnitude and opposite direction, but to the loss of momentum of the first through the mechanism we have describe and which is equal to the momentum is imparts to the second body. Newton's third law of motion is special case of the laws of conservation of momentum of QGD.

Consider the same setup as above. The third law says that $\|\Delta\vec{P}_b\| = x m_b$. Now, if $\vec{P}_a < x m_b$, the momentum of a , which is the maximum momentum that it can impart, is smaller than the minimum allowable change in momentum of b . Hence b must emit back photons in opposite direction whose momentum is equal to the momentum of the photons emitted by a . Hence the Newton's third law of motion.

Case 3

So far we have discussed the special cases of the physics of collision for spheres of similar volume which trajectories coincide. The same laws apply for all cases and when we take into account different angles and directions we find that:



$$\sum_{i=1}^{n_a} m_{\gamma_i} c = (v_a - v_b) m_a \text{ and}$$

$\sum_{j=1}^{n_b} m_{\gamma_j} c = (v_b - v_a) m_b$ where v_a is the speed component of a towards b at the point of impact and v_b is the speed component of b towards a at the point of impact.

Now since $\|\Delta \vec{P}_a\| = x m_a$ and $\|\Delta \vec{P}_b\| = x' m_b$

and since $x m_a \leq \sum_{j=1}^{n_b} m_{\gamma_j} c < (x+1) m_a$

and $x' m_b \leq \sum_{i=1}^{n_a} m_{\gamma_i} c < (x'+1) m_b$, the

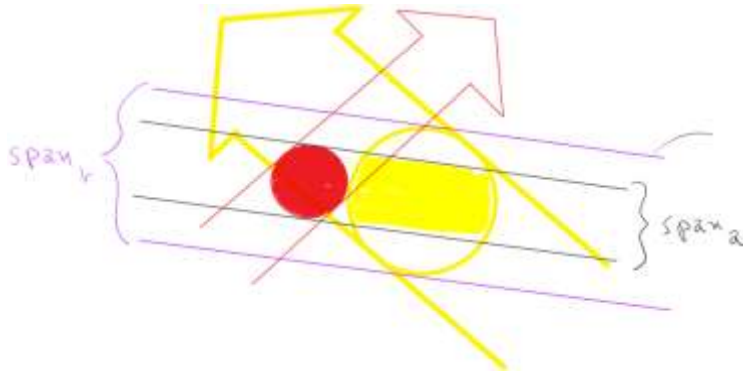
momentum carried by photons emitted by a that exceed the allowed change in momentum of b will be emitted, reflected or refracted (generally as heat) as will the momentum carried by photons emitted by b which exceed the allowed change in momentum of a .

We will now see how the laws that govern gravitational and non-gravitational change in momentum can be used to describe the dynamics of any system at larger scales.

Generalization of Momentum Transfer

Objects that collide are generally not spheres and even when they are, they are generally not of similar dimensions, mass, composition, etc.

If R_a and R_b are the regions occupied by a and b respectively prior to impact. If $span_a$ is the regions of space spanned by a in direction of b and $span_b$ that of b in direction of a then for bodies then:



$$\|\vec{P}_{a \rightarrow b}\| = (v_b - v_a) m_a \frac{R_a \cap S_a \cap S_b}{R_a} \text{ and } \|\vec{P}_{b \rightarrow a}\| = (v_b - v_a) m_b \frac{R_b \cap S_a \cap S_b}{R_b}.$$

In the figure above, a is represented by the sphere on the left and $R_a \cap S_a \cap S_b$ is shown in red. Similarly, $R_b \cap S_a \cap S_b$ is in yellow. In this special illustrated here, $R_a = R_a \cap S_a \cap S_b$ so that

$$\|\vec{P}_{a \rightarrow b}\| = (v_b - v_a)m_a.$$

Note that non-gravitational acceleration is always a result of momentum transfer as described in this section. The same principles apply whether momentum is transferred from one solid object or from a group of particles such as in a gas. It follows that non-gravitational forces are not forces but the effects of momentum transfer and the so-called force is simply the momentum transferred.

Electromagnetic Effects

As a consequence of QGD's axiom set, in its initial state the universe only existed free $preons^{(+)}$ uniformly distributed in quantum-geometrical space, itself [dimensionalized by the interactions between \$preons^{\(-\)}\$](#) .

$Preons^{(+)}$ eventually combined to form particles and particles combined to form progressively more massive structures. The first particles to be formed were neutrinos, constituting the cosmic neutrino background and later formed the photons that form the cosmic microwave background radiation⁴. The isotropy of $preons^{(+)}$ in the initial state of the universe explains the isotropy of the CMBR (we will show in the [Cosmology](#) section that such a universe gives rise to the observable universe without all the problems associated with the big bang theory).

However, observations suggest that most $preons^{(+)}$ in the universe are still free or form particles which momentums are too small for instrumental observation (that is: $\|\vec{P}_a\| < m_e$). These constitute what we may call the preonic background or preonic field. Magnetic fields are regions of the preonic field polarized through interactions with charged particles. It follows that so-called charged particles do not have an intrinsic electrical charge. The effect of attraction and repulsion between charged particles depend entirely on the particles relative position and orientation in the polarized preonic field in the neighbouring regions of the particles which, because of their dynamic structure, reflect or absorb free $preons^{(+)}$ directionally. We will show that the repulsion or attraction is proportional to the product of preonic density by the spin angular momentum over the square of the distance.

As two electrons get closer, the repulsion between them will increase following the inverse square law but will drop to zero when they get in close enough proximity, leaving only gravity between them.

⁴ The mechanism of formation of particles and structures will be discussed in detail a section dedicated to the topic.

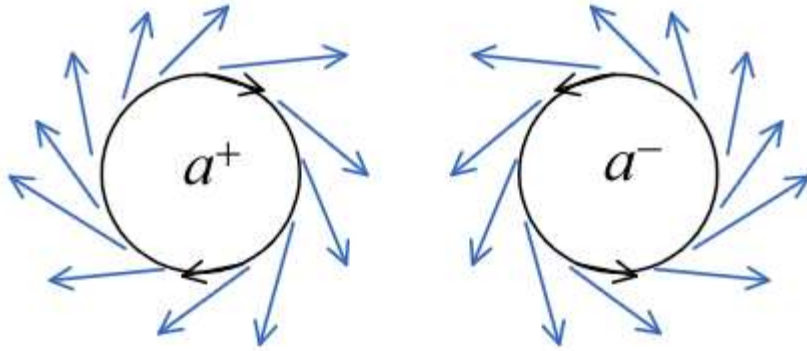
The Electromagnetic Effects of Attraction of Repulsion

The preonic field is composed of free $preons^{(+)}$ uniformly distributed in quantum-geometrical space. Free $preons^{(+)}$ interact with particles or structures matter in accordance with [the laws of momentum](#) which as we have seen govern [preonics](#) of which is a generalization of optics.

When interacting with a particle or structure, $preons^{(+)}$ are absorbed and emitted following the structure of the particle or structure. When the components of a particle or structure are random, the absorbed and reflected $preons^{(+)}$ are also random so that the momentum of the

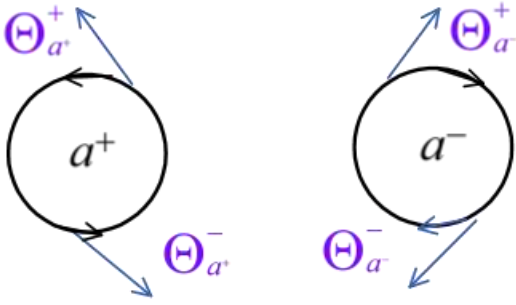
neighbouring preonic field $\vec{\Theta}_a$ is equal to zero. That is: $\vec{P}_{\vec{\Theta}_a} = \sum_{i=1}^{m_{\Theta}} \vec{c}_i = \vec{0}$ where \vec{c}_i is the

momentum vector of a neighbouring $preon^{(+)}$ made of m_{Θ} number of $preons^{(+)}$.



However, when the components of the particle or structure (an electron for example) are aligned, the absorbed and reflected $preons^{(+)}$ will consequently be

aligned. The reader will note that though we may call such particles or structures charged, QGD predicts that particles have no intrinsic charge and would be better described by the term *polarizing particles* (or structure). The interactions between the preonic field and a polarizing particle or structure causes the polarization the preonic field and what we commonly refer to as a magnetic field. From the discussion about optical reflection, we know that the direction of the reflection will depend on the direction of the particles the $preons^{(+)}$ will interact with. The figure above is a diagram that illustrates the dependency of the reflection of $preons^{(+)}$ on the orientation of a particle or structure. The black vectors represent the direction of the components of the particles or structures a^+ and a^- , and the blue vectors represent the polarization of the preonic field in the regions neighbouring them.



When two charged particles or structures come into proximity, they each interact with each other's polarized preonic field. The figure on the left shows how we will represent, and label charged particles or structures and the interacting regions of the polarized preonic field.

Compton Scattering and the Repulsion and Attraction of Charged Particles.

We have shown in the [section on reflection of light](#) that when applying the laws of momentum to the interaction between photons and atomic electron that the Compton scattering occurs when

$\vec{P}_{\gamma} > \vec{P}_{e^-}$ and the inverse Compton scattering when $\vec{P}_{\gamma} < \vec{P}_{e^-}$ where γ is the incident photon

and \vec{P}_{γ} and \vec{P}_{e^-} are respectively the momentum of the *preons*⁽⁺⁾ emitted by the electron and the momentum imparted by the photon with which it interacts. Conservation of momentum requires that the momentum of the electron must change by a vector of equal magnitude but

inverse direction of the sum of \vec{P}_{γ} and \vec{P}_{e^-} . That is, $\Delta\vec{P}_{e^-} = -\left(\vec{P}_{\gamma} + \vec{P}_{e^-}\right)$. This implies that if

$\vec{P}_{\gamma} > \vec{P}_{e^-}$ then the momentum vector of the electron will increase in the direction opposite of

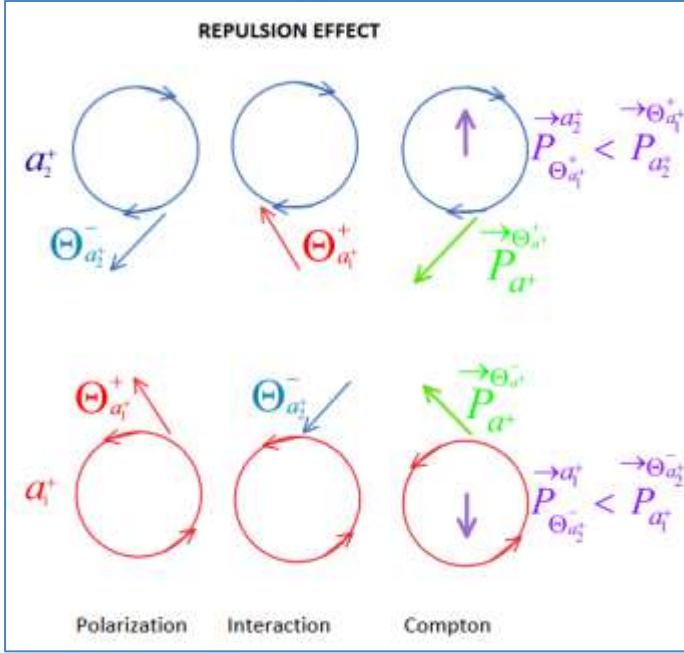
the point of interaction by $\Delta\vec{P}_{e^-}$. Inversely, if $\vec{P}_{\gamma} < \vec{P}_{e^-}$ then the electron's momentum vector will

increase towards the point of interaction by $\Delta\vec{P}_{e^-}$. Whether we have a Compton or reverse Compton scattering depends on the relative direction of the photon and electron (or particle or structure). That is, based on the laws of momentum, if the photon and electron at the point of

interaction move directly towards each other, then $\vec{P}_{\gamma} > \vec{P}_{e^-}$ and if their trajectories intersect

tangentially, then $\vec{P}_{\gamma} < \vec{P}_{e^-}$. The Compton scattering and its inverse are special cases of preonic

interactions which can explain the effects of repulsion and attraction of charged particles.



The figure on the left illustrates the interaction between two oppositely charged particles (a^+ and a^-). The circular vectors represent the angular momentum of the particles and the blue and red vectors correspond to the direction of the polarization preonic field respectively. Since the polarization of $\vec{\Theta}_{a_1^+}$ is opposite to orientation

of a_2^+ then $\vec{P}_{\vec{\Theta}_{a_1^+}^+} < \vec{P}_{a_2^+}$ and

$\Delta\vec{P}_{a_2^+}$ will point away from $\vec{\Theta}_{a_1^+}$, thus a_2^+ will move away from a_1^+ .

Similarly, the polarization of $\vec{\Theta}_{a_2^-}$ is opposite the orientation of a_1^+ so that $\vec{P}_{\vec{\Theta}_{a_2^-}^-} < \vec{P}_{a_1^+}$,

consequently a_1^+ will move away from a_2^+ . This explains the effect of repulsion between two similarly charged particles (and structures).

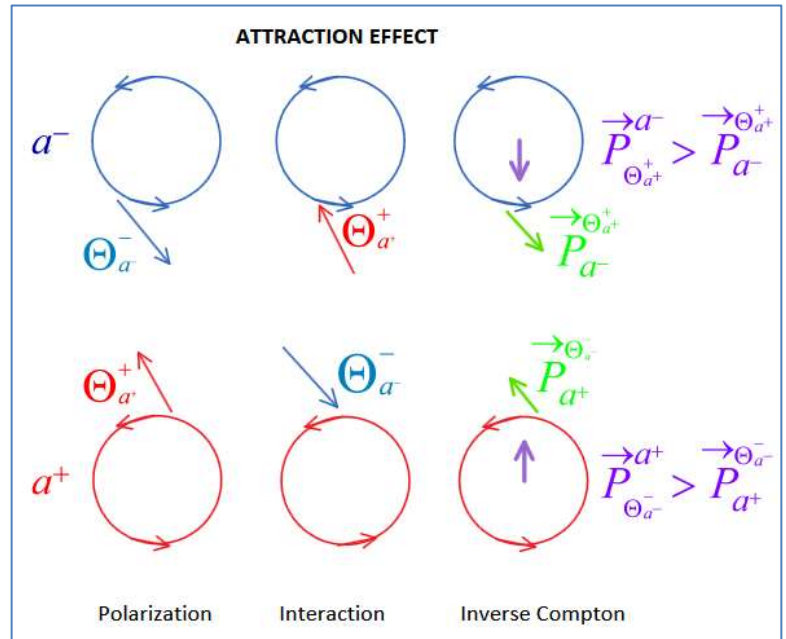
In the figure on the right, we have two particles of opposing charges. Here since the polarization of the region $\vec{\Theta}_{a^+}$ is opposite to the orientation of a^- and the region $\vec{\Theta}_{a^-}$ is polarized in opposite the orientation of a^+

then $\vec{P}_{\vec{\Theta}_{a^+}^+} > \vec{P}_{a^-}$ and

$\vec{P}_{\vec{\Theta}_{a^-}^-} > \vec{P}_{a^+}$ and as a result $\Delta\vec{P}_{a^+}$

will point to a^- and $\Delta\vec{P}_{a^-}$ will point to a^+ . Therefore a^+ and

a^- will move towards each other and appear to be attracted.



As we have shown, the observed repulsion between like charges and attraction between particles does not result from repulsion and attraction between the particles themselves but from their interactions with the preonic regions polarized between them.

Also, since the polarized $preons^{(+)}$ are emitted radially from a charged particle or structure, the intensity or momentum of the polarized region follows the inverse square law. In fact, the inverse square law of the momentum of a magnetic field is a consequence of QGD's preonics.

Interaction between Large Polarizing Structures and the Preonic Field

Large structures that have aligned polarizing particles behave as one single polarizing particle. The main difference is that the effect of a large number of bounded and aligned polarizing particles creates more intense polarization over a much larger region of the preonic field.

Based on QGD's description electromagnetic effect, we can infer that the momentum of the preonic field polarized by a particle is proportional to the product of the magnitude of angular spin momentum of the particle by the density of the preonic field. That is:

$$\vec{\Theta}_a^{+/-} \propto \|\vec{S}_a\| dens_{p^{(+)}} \vec{C}, \text{ where } a \text{ is a polarizing particle, } \vec{S}_a \text{ and } dens_{p^{(+)}} = \frac{m_R}{Vol_R}, \text{ that is,}$$

the number of $preons^{(+)}$ in the region R and \vec{C} is the fundamental momentum .

The momentum imparted to a particle b by a preonic field polarized by a particle a at a distance

$$r \text{ is } \|\Delta\vec{P}_b\| \propto \frac{\|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\|}{r^2} \text{ where } \vec{\Theta}_a^{+/-} \text{ is the momentum of the polarized preonic field generated}$$

by a and \vec{S}_b is the spin angular momentum of the interacting particle or structure.

Note: In a following section, we will discuss how the dynamics of atomic electrons follow from QGD's laws of momentum.

Electromagnetic Acceleration Particles and Theoretical Limits

As we have seen [here](#), the momentum \vec{C} of a $preon^{(+)}$ is intrinsic and fundamental. All properties are invariable except for their trajectories.

When a magnetic field imparts momentum to a polarizing particle, QGD predicts:

1. The mass of the particle increases by the sum of $preons^{(+)}$ it absorbs (which mechanism we describe here),

2. Its momentum increases by the sum momentum of the absorbed *preons*⁽⁺⁾,
3. As consequence of the constancy of the momentum of *preons*⁽⁺⁾, the spin angular momentum of a particle must decrease as its linear momentum increases. The follows from the relation $\sqrt{\|\vec{P}_b\|^2 + \|\vec{S}_b\|^2} = m_b c = E_b$ and consequently
4. the polarization potential of a particle being a function of its spin angular momentum, a particle becomes increasingly less polarizing as it gains linear momentum, thus its capacity to interact with the preonic field decreases. In other words, the particle becomes increasingly neutral.⁵

The momentum imparted by a uniform magnetic field to a polarizing particle⁶ is proportional to the product of the momentum of the momentum of the magnetic field, by the distance it travels, by the angular spin momentum of the particle.

The total momentum imparted by a magnetic field is then given by $\sum_{i=1}^n \|\Delta \vec{P}_b\| \propto \|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\| (d_x)$

and $\sum_{i=1}^n \|\Delta \vec{P}_a\| \propto \|\vec{\Theta}_b^{+/-}\| \|\vec{S}_a\| (d_x)$ where n is the number of momenta imparting events along the

particle's trajectory. And the momentum imparted by the magnetic field for each individual event must equal or greater than the [minimum permitted change in momentum](#) that is:

$$\|\Delta \vec{P}_b\| = x m_b \text{ or } \|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\| = x m_b .$$

Also, $\sqrt{\|\vec{P}_b\|^2 + \|\vec{S}_b\|^2} = m_b c$, and $\Delta \vec{P}_b \propto \|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\|$ implies that the momentum imparted by a uniform magnetic field decreases as its linear momentum increases and as a consequence we can predict that the particle will cease to be accelerated by the magnetic field when its spin angular momentum falls below a certain value such that $\|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\| < m_b$. Below this minimum value, a magnetic field, not matter how powerful, will have no effect. It follows that the particles can not be accelerated or redirected by a magnetic field, which would lead to greater loses of accelerated particles in a circular electromagnetic accelerator than with a linear accelerator.

⁵ This could be observed experimentally as a greater loss of accelerated particles in circular accelerators than in linear accelerators due to inefficiency of circular accelerator to keep particles in the loop after they reach a certain momentum.

⁶ The choice of the term "polarizing particle" instead of "charged particle" reflects the description of electromagnetic interactions which according to QGD results from the polarizing effect of such particle on the preonic field. QGD predicts that particles do not have intrinsic electric charges as held by the standard model.

Asymmetric Polarization of the Preonic Field and Atomic Neutrality

It is currently believed that the electromagnetic interaction between any two charged particles at a given distance will have the same absolute value. The repulsion effects of any two like-charged particles is predicted to be same regardless of the type of particle as should the attraction between any two oppositely charged particles.

But if, as we have suggested, particles have no intrinsic charge and electromagnetic repulsion and attraction between particles is due to their interactions with the preonic field which so-called charged particles have polarized, then it follows the repulsion or attraction between particles will be different depending on their type. That is, the momentum imparted by attraction or repulsion between two different types of particles is not symmetric.

In the figure below, the circles labeled a and b respectively represent two different types of particles electromagnetically interacting. The red and green arrows indicate the direction of polarizations of the preonic field from a and b . The momentum that can be imparted to one

particle interacting by the other's polarized field is $\Delta \vec{P}_a \propto \frac{\|\vec{\Theta}_b^{+/-}\| \|\vec{S}_a\|}{r^2}$ (green arrows) and

$\Delta \vec{P}_b \propto \frac{\|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\|}{r^2}$ (red arrows touching b). It follows that $\|\vec{\Theta}_b^{+/-}\| \|\vec{S}_a\| \neq \|\vec{\Theta}_a^{+/-}\| \|\vec{S}_b\| \rightarrow$

$\Delta \vec{P}_a \neq \Delta \vec{P}_b$. From this, we can predict that the momentum imparted through the electromagnetic interactions between a proton and an electron will differ from that between a proton and a muon, or between a positron and an electron. This allows QGD to make unique predictions that distinguishes from classical electrodynamics.

◀

a

b

This prediction may be tested experimentally by comparing measurements of electromagnetically imparted momentums of particles to measurements of gravitationally imparted momentums.

which should show discrepancies between the theoretical assumption of their intrinsic electrical charges and their electrical charged derived from measurements.

If classical electrodynamics is correct and particles have intrinsic charges, then $\frac{\Delta \vec{P}_a}{\Delta \vec{P}_b} = \frac{\Delta \vec{G}_a}{\Delta \vec{G}_b}$ where $\Delta \vec{P}_x$ is an electromagnetic imparted momentum and $\Delta \vec{G}_x$ is gravitationally imparted momentum.

If QGD is correct and particles have no intrinsic charges, then $\frac{\Delta \vec{P}_a}{\Delta \vec{P}_b} \neq \frac{\Delta \vec{G}_a}{\Delta \vec{G}_b}$.

Atomic Neutrality and Valence

If electrons and protons do not have intrinsic electric charge and interact differently with the preonic field, then to achieve atomic electrical neutrality is only achieved when $\vec{\Theta}_{p^+}^+ = \vec{\Theta}_{e^-}^-$ where $\vec{\Theta}_{p^+}^+$ is the momentum of the polarization by the protons and $\vec{\Theta}_{e^-}^-$, that by the electrons, both taken outside the atomic radius.

The chemical valence of an elements can then be predicted from the relation between the protons and electrons polarization. We have two possibilities:

1. $\left\| \vec{\Theta}_{p^+}^+ + \vec{\Theta}_{e^-}^- \right\| > 0$; two more atoms can form molecules. The number of chemical bonds

depends on the valences of bounding atoms. Here $valence = \frac{\left\| \vec{\Theta}_{p^+}^+ + \vec{\Theta}_{e^-}^- \right\|}{\left\| \vec{P}_{e^-} \right\|}$ where \vec{P}_{e^-} is

the orbital momentum of outer electrons of atoms.

2. $\left\| \vec{\Theta}_{p^+}^+ + \vec{\Theta}_{e^-}^- \right\| \leq 0$; atoms that are chemically inert, thus cannot form chemical bonds with other atoms.

#

Preonics (foundation of optics)

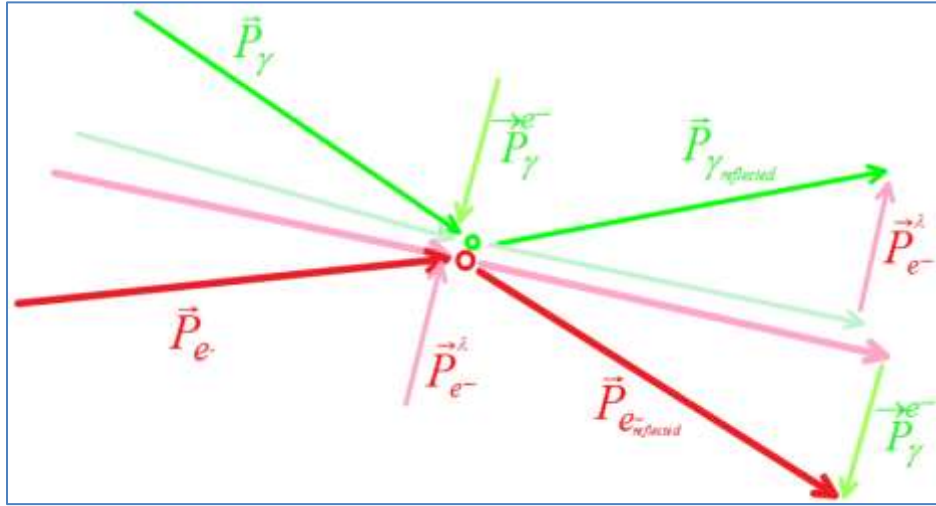
In this section we will show that optics, or the behaviour of light, is governed the [laws of momentum](#).

In fact, if QGD is correct, the same equations may be used to describe the dynamics of interacting objects however small or large they may be.

Reflection of Light

The third law of momentum we derived from the axiom set of QGD says that momentum can change only by discrete amounts. That is: $\|\Delta \vec{F}_a\| = xm_a$ where $x \in N$ and a can be any particle or material structure.

When the trajectory of a photon γ and that of an electron e^- intersect, the same mechanism we described earlier applies. That is, γ will emit *preons*⁽⁺⁾ in the direction of e^- such that $\vec{P}_{\gamma}^{e^-} = \vec{P}_{\gamma} \cos \theta_1$ where $\vec{P}_{\gamma}^{e^-}$ is the momentum vector projection of the photon γ in direction of e^- , \vec{P}_{γ} is the momentum vector of γ and θ_1 is the angle between \vec{P}_{γ} and the line connecting the centers of γ and e^- . Similarly, $\vec{P}_{e^-}^{\gamma} = \vec{P}_{e^-} \cos \theta_2$.



Preons⁽⁺⁾ emitted by the electron will be absorbed by the photon so that $\vec{P}_{\gamma_{reflected}} = \vec{P}_{\gamma} - \vec{P}_{\gamma}^{e^-} + \vec{P}_{e^-}^{\gamma}$ and $\vec{P}_{e^-_{reflected}} = \vec{P}_{e^-} - \vec{P}_{e^-}^{\gamma} + \vec{P}_{\gamma}^{e^-}$ as a result, γ will and e^- be reflected from each other as shown in

the figure above. This mechanism describes and explains the [Compton scattering](#) when $\vec{P}_{\gamma} > \vec{P}_{e^{-}}$ and inverse Compton scattering when $\vec{P}_{\gamma} < \vec{P}_{e^{-}}$.

Refraction of Light

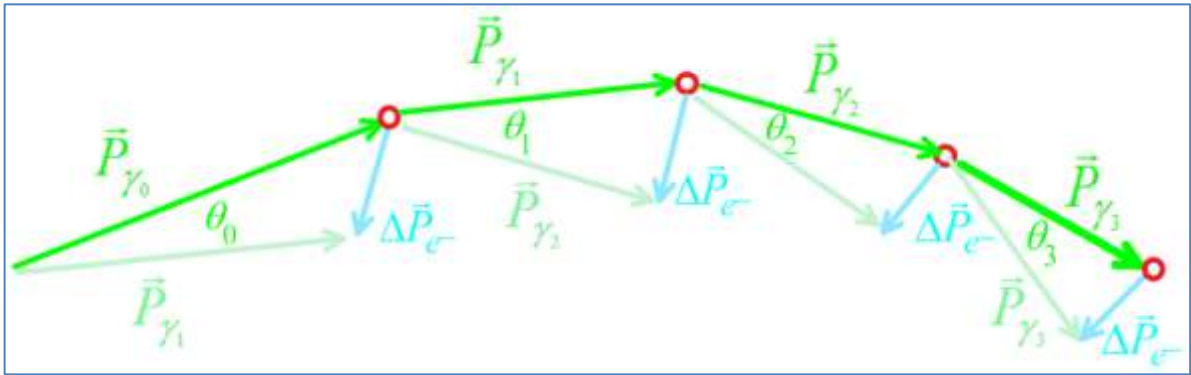
Changes in momentum of an electron are discrete increments proportional to its mass, that is, $\|\Delta\vec{P}_{e^{-}}\| = m_{e^{-}}$.

Now consider a photon γ_0 interacting with an atomic electron with $xm_{e^{-}} \leq \left\| \vec{P}_{\gamma} \right\| < (x+1)m_{e^{-}}$

where \vec{P}_{γ} is the momentum vector of the photon emitted by γ_0 in direction of e^{-} as a component of the interaction as we explained earlier, and $\vec{P}_{e^{-}} \ll \vec{P}_{\gamma}$.

To be consistent with the laws of momentum transfer, $\Delta\vec{P}_{e^{-}} = m_{e^{-}} \frac{\vec{P}_{\gamma_0}}{\left\| \vec{P}_{\gamma_0} \right\|}$ so upon absorption of

the *preons*⁽⁺⁾ emitted by γ_0 the electron must emit a photon λ_1 such that $\vec{P}_{\gamma_1} = \vec{P}_{\gamma_0} - \Delta\vec{P}_{e^{-}}$ (see figure below). This is the basic mechanism of refraction.

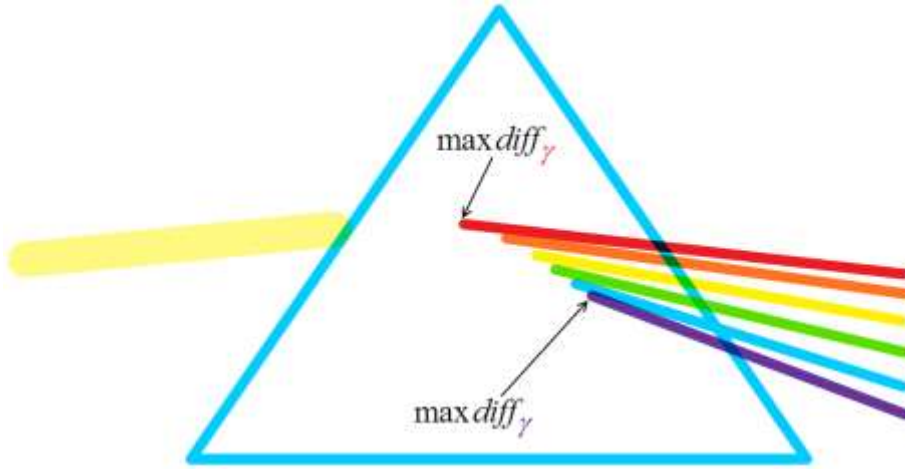


From the equation, we see that θ_0 , the angle between γ_0 and γ_1 (angle of refraction), is inversely proportional to \vec{P}_{γ_0} . That is, the greater the momentum (which corresponds to higher energy or higher frequency in accepted physics), then the greater the refraction for a single interaction. But the refraction of light, by a prism for example, is the result of a series of interactions.

That is: since $xm_{e^-} \leq \left\| \vec{P}_{\gamma_0}^{e^-} \right\| < (x+1)m_{e^-}$, then for $i \geq x+1$ we have $\left\| \vec{P}_{\gamma_i}^{e^-} \right\| < m_{e^-}$ and

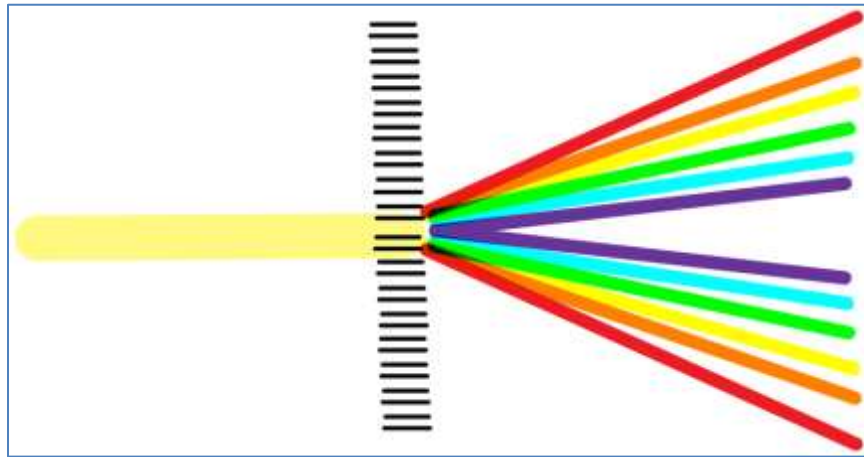
$\vec{P}_{\gamma_i} = \vec{P}_{\gamma_{i+1}}$ and as a consequence $\theta_i = 0$. So there is no refraction for photons once $\left\| \vec{P}_{\gamma_i}^{e^-} \right\| < m_{e^-}$.

. The point at which a photon achieves maximum refraction is directly proportional to its momentum and this produces the colour separation by prism.



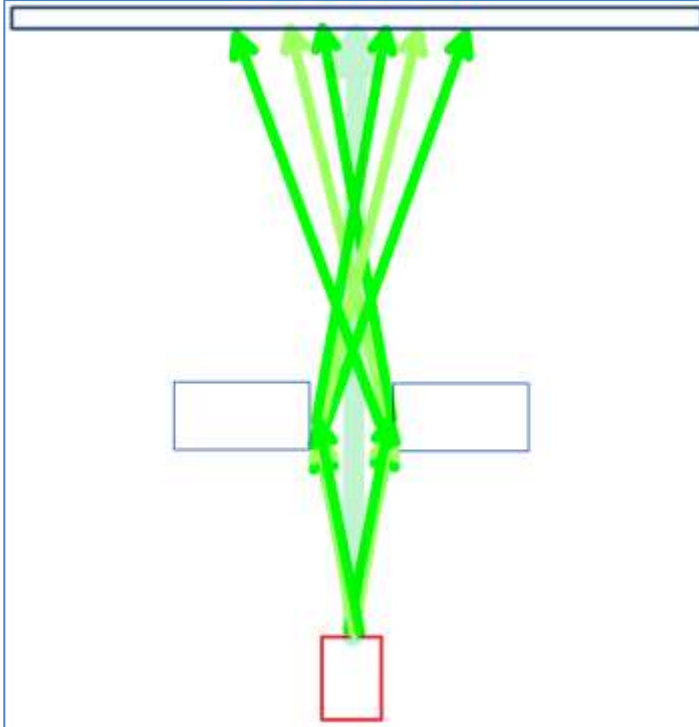
Note that the shape of the prism is ideal as it allows for photons of different momentums to achieve maximum diffraction.

If the number of refractive interactions is lower than what is necessary for photons to achieve maximum refraction, then the colours will be separated due to reflection and as we have seen, the angle of reflection is smaller the higher the momentum is. That explains why refraction using a grid is smaller for photons with higher momentums than photons with lower momentums.



Diffraction of Light

Diffraction is a simple consequence of reflection, that is, the interaction between light and matter and not, as thought, between light waves.



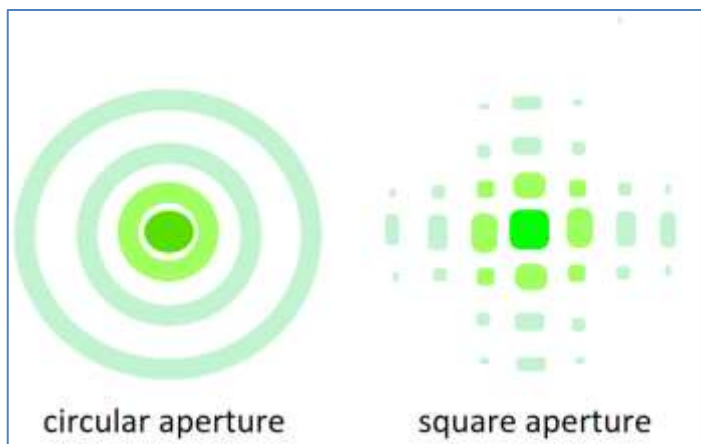
The light bands of diffraction patterns correspond to the allowed changes in momentum of particles or structures and the dark bands correspond to the forbidden changes in momentum.

The bands will appear if there is one source of light and the photons composing the light are have similar momentum. Applying our understanding of reflection of light, we find that the reflection angle of a photon depends not only on its angle of incidence but also on its momentum. The smaller the angle, the smaller will be the momentum from the electron it interacts with and the smaller will the momentum

and angle of reflection of the reflected photon. The angle of reflection of a photon is close to but not equal to the incident angle.

In a strict description the reflection, we must also consider that that only certain changes in momentum are allowed as per our description of momentum and momentum transfer we saw

here. So if $\vec{P}_e^{\rightarrow\gamma}$ is the momentum emitted by the electron in direction of the photon γ with



which it interacts and if

$$xm_\gamma < \vec{P}_e^{\rightarrow\gamma} < (x+1)m_\gamma, \quad \text{then}$$

$\Delta\vec{P}_\gamma = xm_\gamma$ so that all photons within a range of incident angle will be reflected at the same exact angle, but that none will be reflected at angles in the between the exact angle of reflection (this is only true of course for photons of

the same momentum). The result will be as described in the figure above.

The width between the bands but is proportional to difference between the allowable momentums changes they correspond to given a slit of the same depth and width.

As for the number of dark fringes, we will show in the next section that it is proportional to the number of allowed changes in momentum within the angles of diffraction permitted by the

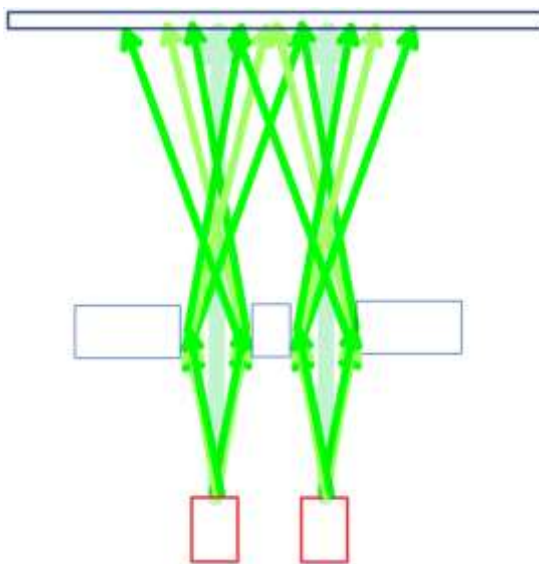
aperture. That is: $n_{fringes} = 2 \left\lceil \frac{\|\vec{P}_y \cos \theta_{max}\|}{m_{e^-}} \right\rceil$ where θ_{max} is half the aperture angle and $n_{fringes}$ is

the number dark fringes on the x or y axis.

As for the pattern of diffraction, it will depend on the shape of the aperture. Applying the equations we have introduced we can predict the patterns generated by a group of photons.

Fringe Patterns from Double-slit Experiments

Following the failure of classical physics theories to explain the interference patterns observed in double slit experiments and other light diffraction experiments and because of the similarities



between these patterns and the interference patterns generated by waves at the surface of a liquid, physicists deduced that light was behaving as a wave which led to the so-called wave-particle duality of light. Since the particle model could explain phenomena such as the photoelectric effect and since the wave model of light described the interference patterns of light, it made sense to deduce that light had to be corpuscular or wave-like depending on the experiment performed on it. But what experiments actually showed is that neither accepted models of light could explain both behaviours and emphasized the need for a new

theory.

The patterns generated in double-slit experiment are thought to be the results of interferences between light waves, but they can be better understood in terms of the reflection and absorption patterns of photons through a mechanism consistent with the laws governing optics (or more generally, preonics) .

Though we describe the double-slit experiments that use photons, the same explanation applies for electrons or any other particle.

Single Slit Experiment

We will first describe single slit experiments.

The momentum vector components that can be imparted to an electron is given by $\|\vec{P}_\gamma \cos \theta\|$ where θ is the angle between the \vec{P}_γ and \vec{P}_{e^-} , but from the [laws of momentum](#) we know that

the momentum imparted by γ must be such that $\|\Delta\vec{P}_{e^-}\| = \alpha m_{e^-}$ and we have $\alpha = \left\| \frac{\vec{P}_\gamma \cos \theta}{m_{e^-}} \right\|$.

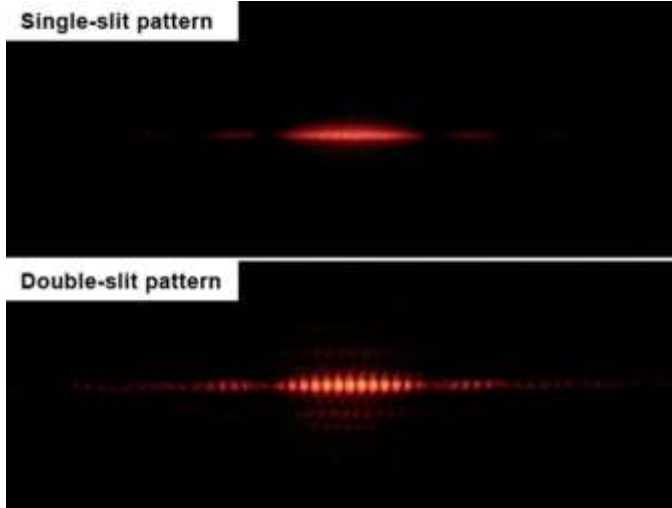
So the momentum that can be imparted to an electron by a photon is $\|\Delta\vec{P}_{e^-}\| = \left\| \frac{\vec{P}_\gamma \cos \theta}{m_{e^-}} \right\| m_{e^-}$.

We see that when \vec{P}_γ is perpendicular to \vec{P}_{e^-} , $\|\vec{P}_\gamma \cos \theta\| = 0$ so that the photon is reflected back. As we move away from that angle towards, the photon will be absorbed when θ is such that $\|\vec{P}_\gamma \cos \theta\| = m_{e^-}$. This will show as a dark fringe on the screen which width depends on the width of the slit and the distance the slit and the screen.

The number of absorption fringes will be equal to $n_{fringes} = 2 \left\| \frac{\vec{P}_\gamma \cos \theta_{\max}}{m_{e^-}} \right\|$.

Double-Slit Experiments

When there are two slits, two or more photons from different angles can simultaneously interact with an electron. In the case of two photons, they will be absorbed if $\|\vec{P}_{\gamma_1} \cos \theta_1 + \vec{P}_{\gamma_2} \cos \theta_2\| = \alpha m_{e^-}$. If this condition is not met, then both photons γ_1 and γ_2 will be reflected.



At the centre of the screen (which is the point on the screen that is at equal distance from both slits),

$$\|\vec{P}_{\gamma_1} \cos \theta_1 + \vec{P}_{\gamma_2} \cos \theta_2\| = 0 \text{ and the}$$

photons will be reflected. But away from the centre, there will be angles θ_1 and θ_2 such that

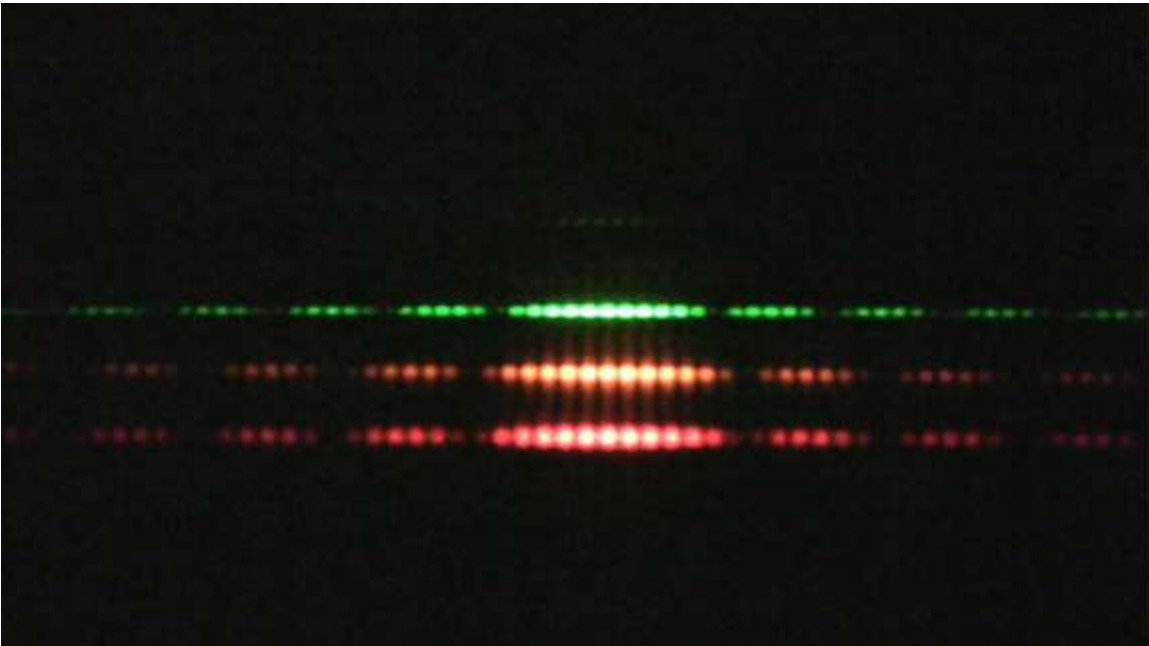
$$\|\vec{P}_{\gamma_1} \cos \theta_1 + \vec{P}_{\gamma_2} \cos \theta_2\| = \alpha m_{e^-}$$

creating dark fringes which width depend on the width of the slits and the distances from each other and

the screen.

As for the number of dark fringes (absorption fringes), it is a function of the angular ranges of photons from the two slits.

From the mathematical description we find that the momentum of the photons will affect the distances between the fringes. Everything else being equal, the greater the momentum of photons, the closer adjacent absorption fringes will be as shown in the picture below which compares the patterns emerging from photons of three momentums (energies).



Therefore, the distance between absorption fringes is inversely proportional to the momentum of the photons used in the experiments.

As we have seen in this section, the emergence of fringe patterns in double-slit experiments can be explained in terms of absorption and reflection of photons using the singularly corpuscular model of light proposed by QGD. In fact, QGD's corpuscular model and the laws of momentum together explain all optical phenomena which are normally attributed to wave-like behaviour of light. Therefore, all optical phenomena can be described a single consistent set of equations that can replace the distinct equations currently used to describe distinct phenomena.

QGD at Short Distances

QGD is scale independent which implies that dynamic systems, regardless of scale, can be fully described using nothing more than the forces and effects we have introduced in the section [Forces, Interactions and Laws of Motion](#). In this section we will explain how QGD can be applied to describe systems at the smallest scales; scales comprising the nuclear and subnuclear scales, some which are orders of magnitude smaller than nucleons, or even the electron.

We will describe short distance interactions in terms of the gravity, the electromagnetic effect and momentum transfer as discussed in the section [The Physics of Collision and Conservation of Momentum](#).

We will also discuss the problem of stability of nuclear and subnuclear structures, which includes particles that are considered fundamental by dominant physics theories.

The Gravitational Effect at Very Small Distances

QGD describes gravity as the resultant of two fundamental forces, p-gravity and n-gravity, which are respectively attractive and repulsive.

At large scale, the n-gravity component of the equation describes the repulsive effect of space, which is sum of the n-gravity interactions between objects is proportional to the square of the number of *preons*⁽⁻⁾ between them. We saw that repulsive gravity overcomes the attractive

component of gravity beyond the threshold distance d_Λ where $k < \frac{d_\Lambda^2 + d_\Lambda}{2}$ from which point gravity becomes repulsive proportionally to the square of distance.

Observations suggest that $d_\Lambda = 10Mpc$, so that since $\vec{G}^+ + \vec{G}^- = 0$ at $d = d_\Lambda$, and since \vec{G}^+ is independent of distance, assuming the conventional geometrical distances are proportional to discrete preonic distances, we can predict that at $d = 1$, gravity is attractive and approximately 10^{104} times greater than at $d = d_\Lambda - 1$. Therefore, gravity at the nuclear scale can overcome electromagnetic repulsion, thus capable of binding nucleons. Nucleons and their component particles can escape gravity at the smallest scale when the sum of their momentum, the electromagnetic repulsion and punctual momentum transfer from collisions is sufficiently large.

The n-gravity component of gravity is reduced significantly at very short distances so the equation for gravitational interaction between any two nucleons within a nucleus is reduced to the p-gravity component. That is $\vec{G}(n_i; n_j) \approx km_{n_i} m_{n_j} \hat{u}_{i,j}$, where n_i is the i^{th} nucleon of a

nucleus containing j nucleons. So that $\Delta\vec{G}_{n_i} = \sum_{\substack{j=1 \\ j \neq i}}^{n_j} \Delta\vec{G}(n_i; n_j) \hat{u}_{i,j}$.

Below a certain threshold distance between nucleons, if the mass of the nucleus is large enough, the gravitational momentum of a nucleon towards center of mass of the nucleus is greater than the momentum imparted by electromagnetic interaction (electromagnetic repulsion between protons); allowing nucleons to be bounded within the nucleus.

However, the periodic table tells us that stable nuclei of atoms from the second element and on, that the gravitational interaction between protons is insufficient to insure their stability. Neutrons, electromagnetically neutral particles, which increase the mass, hence gravity, without cranking up electromagnetic repulsion are needed. The helium atom, for example, having two protons and two neutrons increases by a factor of three the gravitational magnitude of the p-gravity component of the gravitational interaction between any of its nucleon and the three other nucleons. This increase in gravity compensates not only for the electromagnetic effect but also the momentums of the nucleons, and the potential transfer of momentum due to collision between nucleons, their components or with external particles.

Electromagnetic Interactions between Nucleons

As does the electron, the proton polarizes the preonic field when it interacts (reflects) free $preons^{(+)}$ that intersect with the proton's component $preons^{(+)}$. Magnetic fields are made of polarized $preons^{(+)}$. Therefore, the electromagnetic repulsion between so-called charged particles, is a function of the preonic density, the distance between the particles, and the spin angular momentum of the particles.

At the very short distances of the nuclear scale, the repulsion is also a function of the volume between two charged particles, $Vol(a;b)$, since the number of $preons^{(+)}$ within that volume may be so small that the momentum of the polarized $preons^{(+)}$ with which protons interact is lower than the minimum change in momentum allowed. That is: $\vec{\Theta}_a(a;b) < m_{p^+}$.

Momentum of the preonic field in a given direction is $Vol_R dens_{p^{(+)}} \vec{c}_a$

From this we understand that when $Vol(a;b) < \min_vol$ where $vol_{\min}(a;b)$ is the minimum volume for a given density for which $\vec{\Theta}_a(a;b) \geq m_{p^+}$, that is, the minimum volume between two protons necessary to generate a magnetic field capable of imparting momentum to a proton.

So, if the distance between two protons is such that $Vol(a;b) < \min_vol$, the electromagnetic repulsion between protons is insufficient to impart momentum and protons stop repulsing each other. Up to that minimal distance, there is no repulsion. Beyond the minimal distance the electromagnetic repulsion increases proportionally to $vol(a;b)$ up to the distance at which we

have maximum repulsion and from that point, the electromagnetic repulsion follows the inverse square law.

Nuclear Interactions and the Law and Momentum

If attractive gravity between nucleons is dominant, what keeps the nucleus from becoming a singularity in which they would be reduced to their components? The answer: the very same mechanism that describes momentum transfer during collisions of bodies or particles which is described [here](#).

The electromagnetic repulsion between two protons, as does all charged particles, depends on the preonic field density, the number of free $preons^{(+)}$ they interact with, which itself depends on the preonic density and the number bound $preons^{(+)}$ or m_a with, and on the distance separating and the preonic density $dens_{preons^{(+)}}$. Based on our description of the electromagnetic effect, the interactions between two protons at the nuclear scale are governed by the following equations.

$$[4] \vec{\Theta}(a;b) \propto vol(a;b) dens_{preons^{(+)}} \vec{c}$$

$$[5] \Delta \vec{P}_a > 0 \rightarrow \vec{\Theta}^a(a;b) = x m_a$$

and

$$[6] \Delta \vec{P}_b > 0 \rightarrow \vec{\Theta}^b(a;b) = x m_a$$

$$[7] \vec{\Theta}^a(a;b) = \vec{\Theta}^b(a;b) \text{ where both } a \text{ and } b \text{ re protons.}$$

Note that though the equation [4] holds when a is a proton and b an electron, we must keep in mind that the region polarized by a proton is larger than the region polarized by an electron (protons interact with more free $preons^{(+)}$. The $preons^{(+)}$ components move at velocity \vec{c} in closed paths within the proton and as they do, they interact directly with free $preons^{(+)}$, redirecting and refocusing them. Being composed of much larger number of bound $preons^{(+)}$ proton polarize proportionally a greater number of free $preons^{(+)}$. The “excess” number of polarized $preons^{(+)}$ would contribute to the formation of molecules.

From [1] and [2] and [3] we find the electromagnetic interaction is null at distances $d < d_{\min}$, where at d_{\min} we have $\vec{\Theta}(a;b) = m_a, m_b$. Here again, if $m_a < m_b$, we can have $\Delta \vec{P}_a > 0$ while $\Delta \vec{P}_b = 0$. That would be the case if a is an electron and b a proton.

The relation between the electromagnetic repulsion and gravitational interaction in a stable atomic nucleus is given by

$$\sum_{j=1}^Z \vec{\Theta}(p_i^+; p_{j \neq i}^+) = \sum_{j=1}^A \Delta \vec{G}(p_i^+; \eta_j)$$

where Z is the atomic number, A is the mass number, p_i^+ is a proton of the atomic nucleus and η_i a nucleon.

If $\sum_{j=1}^Z \vec{\Theta}(p_i^+; p_{j \neq i}^+) > \sum_{j=1}^A \Delta \vec{G}(p_i^+; \eta_j)$ then the nucleus is instable (not in equilibrium). The system will resolve itself to equilibrium by the reducing the electromagnetic repulsion. Observations tell us that it does so by reducing the atomic number (the number of protons). This can be accomplished by the conversion of one or more protons into neutrons by emissions of electrons (beta radiation), or by ejecting protons (alpha radiation) which results in a stable nuclear configuration.

After the change in atomic number, it is likely that $\sum_{j=1}^Z \vec{\Theta}(p_i^+; p_{j \neq i}^+) < \sum_{j=1}^A \Delta \vec{G}(p_i^+; \eta_j)$. The

nucleus is stable but still not in equilibrium just yet. The mass of the nucleus must be reduced to achieve equilibrium. From observations, the system will resolve itself by emitting neutral

particles which will reduce gravity by $\sum_{j=1}^A \Delta \vec{G}(p_i^+; \eta_j) - \sum_{j=1}^Z \vec{\Theta}(p_i^+; p_{j \neq i}^+)$.

This may also explain why certain atomic nuclei are unstable and why there is a limit as to their size. As the number of protons increase, the size of the nucleus increases and so does the distances between some protons. If the distances increase beyond the threshold distance, the number of free *preons*⁽⁺⁾ becomes large enough to restore electromagnetic repulsion making the nucleus instable. To reach equilibrium, either the number of protons must decrease and/or the mass neutral mass must increase.

This can be achieved by having one of more protons emits electrons and convert to neutrons in sufficient number to achieve the equilibrium state.

A proton or neutron may then be ejected to bring the size of the nucleus down so that the distances between the protons are below the threshold distance.

An unstable nucleus may also become stable by absorbing neutrons, increasing the mass so that the additional gravity compensates for the repulsion between certain protons or proton may emit an electron, converting to a neutron which then brings stability by reducing or eliminating electromagnetic repulsion within the nucleus.

The reader will note that radioactive decay is attributed here to mechanisms that restores equilibriums states.

Principle of Strict Causality and Equilibrium

From what we have laid out in [The Principle of Strict Causality](#) and the [Fundamentality and the Conservation Law](#) sections, we understand all events are strictly causal. So though probabilistic models may help predict the likelihood of decay events in large statistical samples, the events are not spontaneous but results from sequences of causality related events which mechanisms we have discussed.

QGD Interpretations of Redshift Effects

A consequence of QGD's axiom of discreteness of space implies that all electromagnetic radiations are singularly corpuscular emissions and, as we have seen earlier in this section, the wave-like behaviour of light emerges from interactions between photons and structures which fundamentally are all discrete. Because of its corpuscular nature, the properties of a photon do not change between its emission and detection (unless it interacts with matter along its trajectory), hence the apparent redshift of the emission spectrum occurs either at the source of emission (intrinsic redshift) or during its detection. The redshift therefore does not result from a shift in the momenta of photons along their trajectories between emission and detection but, as explained below, is simply a measurement of the difference between the momenta of photons of the emission spectrum of electrons of a given element from two distinct sources, one the observed source and the other the reference source.

Intrinsic Redshift

We have seen that changes in momentum of electrons obey the law

$$[8] \Delta \vec{P}_{e^-} = \alpha m_{e^-}$$

which imposes that only photons such that

$$[9] \vec{P}_{\gamma} = \alpha m_{e^-} \text{ can be absorbed or emitted.}$$

Equation [1] governs not only changes in momentum that are induced by the absorption of emission of a photon, but also momentum changes resulting from variations in gravity and/or the electromagnetic field effect, the latter resulting from a variation in the preonic density. Hence taking gravity and the electromagnetic effect into account we get:

$$[10] \Delta \vec{P}_{e^-} = \vec{P}_{\gamma} + \Delta \vec{G} + \Delta \vec{\Theta} = \alpha m_{e^-} \text{ where } \Delta \vec{G} \text{ is the variation in gravity and } \Delta \vec{\Theta} \text{ is the variation in the magnitude of electromagnetic interaction of the atomic electron is subjected to.}$$

Since the law of momentum [1] must be obeyed then from equation [3] we see that an increase in gravity or the preonic density or both proportionally decreases the permitted momentum of photons an electron can absorb or emit. Conversely, if gravity and/or the preonic density decrease(s) then the permitted momentum for photons to be absorbed or emitted increases proportionally since

$$[11] \vec{P}_{\gamma} = \alpha m_{e^-} - \Delta \vec{G} - \Delta \vec{\Theta}.$$

An increase in gravity will therefore reduce the momentum necessary for photons to be absorbed or emitted by the source and as a consequence, the absorption and emission spectrum of the source atoms will be redshifted.

The law of momentum and its corollaries describe all possible redshifts effects and implies that all are intrinsic. However, though the redshifts of emission and absorption spectrum are intrinsic, measurements of redshifts are relative, thus depend on the emitting sources and choice of reference sources.

Note. Redshift or blueshift may be due to variations in gravitational or electromagnetic interaction between the electrons and the atomic structure. Also, from $\vec{P}_\gamma = \alpha m_{e^-}$, we can see that redshift or blueshift can also be caused by a change in the mass of electrons following the absorption of a photon. The change of mass of an atomic photon which as we have seen explains the energy difference between two states of atomic electrons may also be a component of the redshift. Hence the complete equation would be $\Delta \vec{P}_{e^-} = \vec{P}_\gamma + \Delta \vec{G} + \Delta \vec{\Theta} + \Delta m_{e^-} = \alpha m_{e^-}$. Variation in the mass of the electrons may be predicted for atoms close to intense source of electromagnetic radiation.

Predictions for Relative Gravitational Redshift

From the above, we know that what is currently understood as the redshift and an emission spectrum is not an intrinsic physical effect. It is in fact not a physical effect at all, but a comparison of between the spectrums of electromagnetic emissions from an observed source of emission and a reference source of emission. The magnitude of the observed redshift depends on the choice of observed and reference sources, thus the energy of observed photons depend on the observer. The usual interpretation of the redshift effect violates the law of conservation of energy. QGD however predicts that the energy of a photon is intrinsic and as a consequence is observer independent.

An observed redshift corresponds to the difference between the magnitudes of the momentum vectors of a photon from an observed source and a photon from a reference source. That is, the observed redshift is given by

$$[12] \ z = \left\| \vec{P}_{\gamma_0} \right\| - \left\| \vec{P}_{\gamma_1} \right\|$$

where \vec{P}_{γ_1} is the momentum of a photon from an observed source and \vec{P}_{γ_0} is the momentum of a photon from within the corresponding emission band of a reference source. Or, since for any

photon we know that $\left\| \vec{P}_\gamma \right\| = \left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\| = \sum_{i=1}^{m_\gamma} \left\| \vec{c}_i \right\| = E_\gamma$ then we equation [5] is equivalent to

$$[13] \ z = E_{\gamma_1} - E_{\gamma_0} .$$

From [5], we see that the intrinsic redshift may be approximated by careful choice of the reference source. Cosmological expansion which we will be discussed in detail in the section on [QGD Cosmology](#) is driven by gravity which at the cosmological scale is repulsive (scale at which structure are separated by distances $d > d_\Lambda$). Structures gravitationally accelerate from QGD's

predicted center of the Universe at a rate proportional to their distance from the center. It follows that all structures are intrinsically redshifted so that the closer a structure is to the center of the Universe, the smaller will be its cosmological acceleration, and the less it will be redshifted. Thus structures that are close to the center of the Universe are the ideal reference sources since $\lim_{r \rightarrow 1} z = \Delta \vec{G} = \Delta \vec{P}_{\gamma_1}$ where r is the distance from the center.

What the Redshift Tells Us

From $\Delta \vec{P}_{e^-} = \vec{P}_{\gamma} + \Delta \vec{G} + \Delta \vec{\Theta}$, we know that the gravitational acceleration of the electron is given by $\Delta \vec{v}_{e^-} = \frac{\Delta \vec{G}}{m_{e^-}}$. From the equivalence principle we find that the gravitational acceleration of the source system S is:

$$[14] \Delta \vec{v}_s = \frac{\Delta \vec{G}_s}{m_s} = \frac{\Delta \vec{G}_{e^-}}{m_{e^-}}.$$

So, if the mass of the system is known, we can derive its gravitational acceleration at the time of emission of the observed photons from its redshift and the intrinsic mass of the electron. However, since we are limited to observations of the relative redshift and since all photon sources in the universe are relatively redshifted or blueshifted, we need to choose a reference source with an intrinsic redshift as close to zero as possible.

Good candidates would be atoms in the void the middle of a cluster of galaxies at distances near the threshold distance d_{Λ} since for $d = d_{\Lambda}$ we have $\vec{G} = 0$ and the relative redshift would then be close to the intrinsic redshift of the observed source that is $\vec{z} \approx \Delta \vec{G}_{e^-}$ and $\Delta \vec{v}_s \approx \frac{\vec{z}}{m_{e^-}}$.

Ideal however would be photons emitted from source at or near the center of the Universe⁷. From [3], such ideal reference photon sources would also be recognizable as sources of the most energetic photons, which in conventional terms with the most highly blueshifted source.

From [1], [2] and [3] we find:

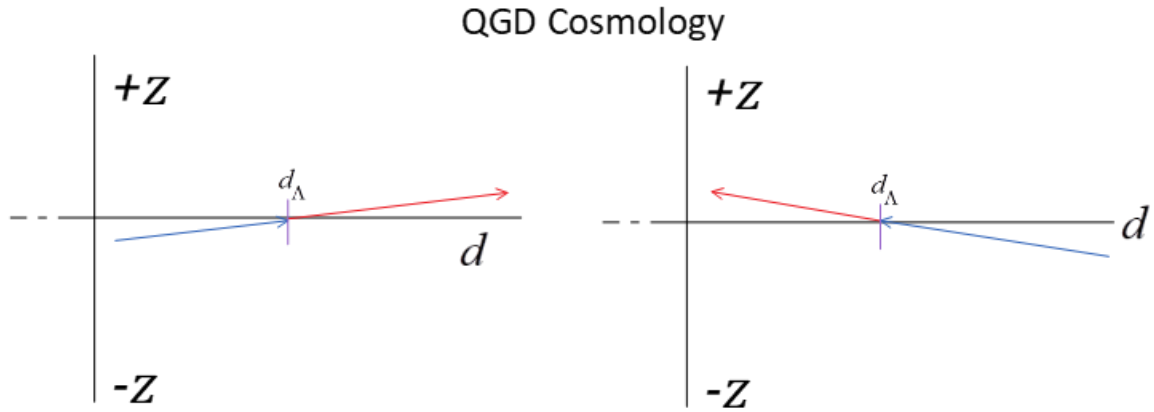
[15] $\Delta \vec{P}_{\gamma_1} - \Delta \vec{P}_{\gamma_0} = \Delta \vec{G}$ where γ_1 is a photon emitted by the observed source and γ_0 is a photon emitted by the reference source. Therefore from QGD's equation for gravity (assuming for now that $\Delta \vec{\Theta} \approx 0$) the redshift (or blueshift) we find that:

- for $d < d_{\Lambda}$, d_{Λ} being the threshold distance below which gravity is attractive, objects moving away from us will be blueshifted while objects moving towards us will be redshifted and,

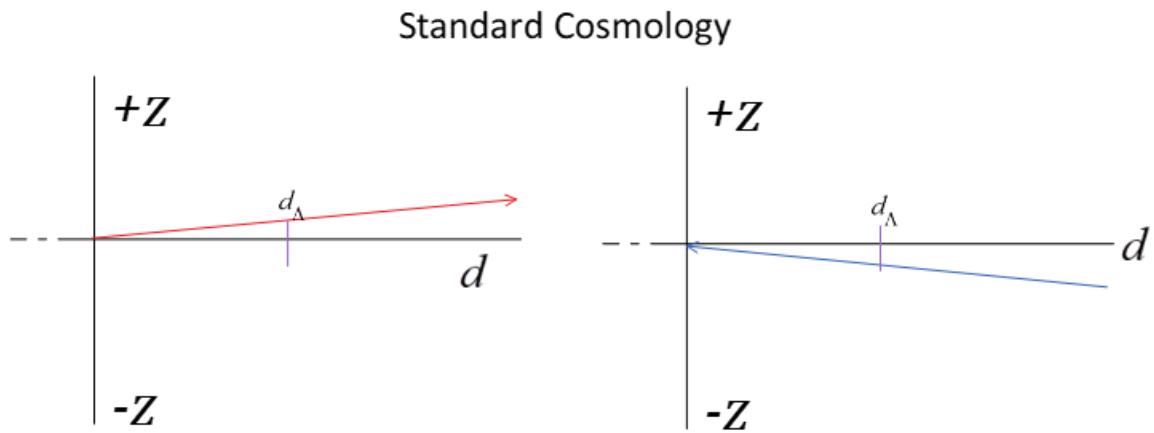
⁷ The [cosmology derived from QGD](#) implies that the universe is finite and has a center.

- for $d > d_{\Lambda}$, lights emitted by objects moving away from us will be redshifted while light emitted by objects moving towards us will be blueshifted.

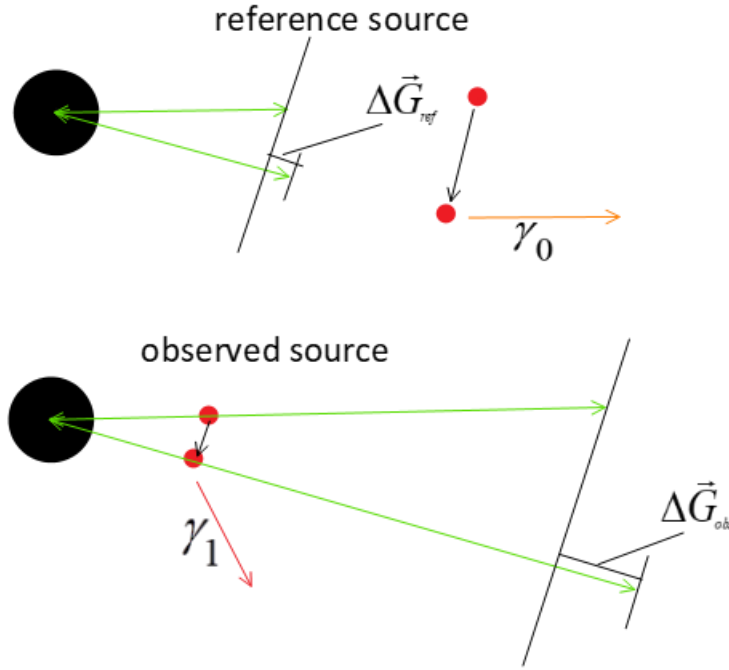
The graphics below compare the distinct predictions of QGD and standard cosmology.



The arrows indicate the direction of motion of the observed object



Noteworthy is that, contrary to standard cosmology, the gravitational redshift and blueshift mechanisms which QGD describe do not violate the laws of conservation of energy. Also, the redshift equation takes into account what is referred to as dark energy (which is caused by gravity becoming repulsive for $d > d_{\Lambda}$); predicting different behaviour of the redshifts and blueshifts for $d < d_{\Lambda}$ and $d > d_{\Lambda}$.



From [3] and [5], we understand that the greater $z \propto \Delta \vec{G}$, thus the effect will be most noticeable when a star moves close to a high-density object such as a black hole. The redshift of the spectrum of a star near a black hole has been recently observed⁸ and though it is taken as confirmation of the [gravitational redshift](#) predicted by general relativity, the observation is also consistent with the predictions of QGD as shown in the figure below where the light from a star orbiting a black hole will be redshifted relative to a reference source orbiting at a larger distance.

It is interesting to note that all redshift effects are described by a single equation (equation [5])) while several different mechanisms are required for the Doppler cosmological redshift, the redshift and the gravitational redshift, but most importantly, the relation expressed in [3] relates the dark energy effect (repulsive gravity for $d > d_\Lambda$), but as we will see in the section on [QGD cosmology](#), it also links dark matter and the electromagnetic interactions between particles (since $\vec{\Theta} \propto \text{preonic_density}$, hence proportional to the density of the dark matter halo).

⁸ <https://arxiv.org/abs/1807.09409v1>

Mapping the Universe

Though the mechanism of the redshift effect is the same at all scales, its interpretations differs depending on the scale of the scope of observations. An increase of the gravitational acceleration affecting an observed source will always cause a shift in the emission spectrum of the atom, but from QGD's equation of gravity we know that, as with Newtonian gravity, the gravitational interaction decreases as a function of distance but it is the opposite beyond the threshold distance d_{Λ} where gravity increases with distance.

When observed and reference sources are separated by distances smaller than the threshold distance d_{Λ} , a reduction in the magnitude of the gravitational interaction an observed object is submitted to will, according to equation [5], result in a blueshift of the emission spectrum compared to that of its previous position while an increase in the gravitational interaction will produce a redshift. This has been observed recently when the light from a star approaching Sagittarius A* was redshifted. However, the opposite will be observed when observed sources are at distances greater than the threshold distance.

Consequently, mapping the observable Universe requires that we apply scale appropriate interpretations of the redshift effect to observations. For electromagnetic signals, taking into account the distance of the source (using luminosity and scattering of photons) allows us to establish the state the Universe at the moment of their emissions.

For gravitational signals, assuming that gravity is instantaneous, all signals describe the changes of state the objects as they occur which implies that all simultaneous gravitational signals correspond to simultaneous events. Therefore, gravitational signals may help us create a map of the universe in "real time."

Different cosmologies provide different interpretations of observational data and draw different maps of the Universe. As we will see in the section on [QGD cosmology](#), QGD predicts that the universe is finite therefore it must have a center and an edge. Interpreted by QGD, the measurements of redshifts draw a map very different from that obtained by applying standard cosmology. But though different QGD's map is not only consistent with observations of stellar objects but consistent with the laws of physics that describe reality at all scales from the most fundamental to the cosmological. QGD's description of the Universe is consistent with the law of gravity and the laws of momentum and does not require spatial dimensions beyond the three that we know, nor does it need any ad hoc particles or mechanisms to explain such things as the dark matter or dark energy effects. QGD describes reality using the smallest possible number of initial assumptions; the minimal axiom set necessary to describe dynamic systems.

We will continue this discussion in the [QGD Cosmology section](#).

Distances and Intrinsic Luminosities of 1a Supernovas

First we need to choose a reference type 1a supernova with the largest blueshift and measure its distance d_{ref} from it parallaxes so as to eliminate physical assumptions (such measurement will be possible using the data from the GAIA or similar mission). Based on QGD's explanation of the redshift effect, we understand that the electromagnetic emission from such a supernova is its intrinsic spectrum.

Once the distance is known, we can calculate its intrinsic luminosity using the formula $L_{ref} = Flux_{\gamma_{ref}} * 4\pi d^2$ where the $Flux_{\gamma_{ref}}$ is the number of photons γ_{ref} of a given momentum or energy (since these properties are numerically equal for photons).

In order to measure the distance of another type 1a supernova (SN) we must determine its redshift. The redshift is used here to determine the position on the redshifted spectrum of the supernova where we will find photons γ_{SN} that have the same intrinsic energy as the reference photons γ_{ref} . $Flux_{\gamma_{SN}}$ is the number of γ_{SN} photons.

If the luminosities of type 1a supernovas are comparable (the accepted assumption), that is: if

$$L_{ref} = L_{SN}, \text{ then } L_{ref} = Flux_{\gamma_{SN}} * 4\pi d_{SN}^2 \text{ and } d_{SN} = \sqrt{\frac{L_{ref}}{4\pi Flux_{\gamma_{SN}}}}.$$

Derivation of the Intrinsic Velocity of Earth from Type 1a Supernovas

Also, using QGD's description of the redshift effect, we can calculate \vec{v}_a , the intrinsic speed of the Earth (or that of any detector in space), using three non-coplanar reference supernovas.

$$\text{Since } (\vec{c}_{\gamma_{SN_i}} - \vec{v}_{a_{SN_i}}) m_{\gamma_{SN_i}} = \Delta \vec{P}_a, \text{ then } \vec{v}_{a_{SN_i}} = \vec{c}_{\gamma_{SN_i}} - \frac{\Delta \vec{P}_a}{m_{\gamma_{SN_i}}} \text{ and}$$

$$\vec{v}_a = \vec{v}_{a_{SN_1}} + \vec{v}_{a_{SN_2}} + \vec{v}_{a_{SN_3}}.$$

Conclusion

If QGD's explanation of the redshift effect is confirmed, then it will be possible to measure the intrinsic speed not only of the Earth (its absolute speed) but of other observable objects and from it, derive the values of other intrinsic properties such as momentum and mass.

Derivations of Predictions of Special and General Relativity

Though the axiom sets of QGD and those of the special and the general relativity are mutually exclusive, our theory is not exempt from having to explain observations and experiments; particularly those which confirm the predictions of the relativity theories.

We will now derive some of the key predictions of special relativity and general relativity and since a new theory must do more than explain what is satisfactorily explain current theories, we will also derive new predictions that will allow experiments to distinguish QGD from the relativity theories.

Constancy of the Speed of Light

Light is composed photons, themselves composites of *preons*⁽⁺⁾ which move in parallel directions.

The speed of a photon is thus

$$v_\gamma = \frac{\left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\|}{m_\gamma} = \frac{\sum_{i=1}^{m_\gamma} \|\vec{c}_i\|}{m_\gamma} = \frac{m_\gamma c}{m_\gamma} = c$$
 which is the fundamental speed of *preons*⁽⁺⁾ and by definition constant.

Why nothing can move faster than the speed of light

We know that $v_a = \frac{\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|}{m_a}$ and that $\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| \leq \sum_{i=1}^{m_a} \|\vec{c}_i\|$ then since $\frac{\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|}{m_a} \leq \frac{\sum_{i=1}^{m_a} \|\vec{c}_i\|}{m_a}$ and

$$\frac{\sum_{i=1}^{m_a} \|\vec{c}_i\|}{m_a} = \frac{m_a c}{m_a} = c$$
 it follows that $v_a \leq c$.

The Relation between Speed and the Rates of Clocks

QGD considers time to be a purely a relational concept. In other words, it proposes that time is not an aspect of physical reality. But if time does not exist, how then does QGD explain the different experimental results that support time dilation; the phenomenon predicted by special relativity and general relativity by which time for an object slows down as its speed increases or is submitted to increased gravitation interactions?

To explain the time dilation experiments we must remember that clocks do not measure time; they count the recurrences of a particular state of a periodic system. The most generic definition

possible of a clock is a system which periodically resumes an identifiable state coupled to a counting mechanism that counts the recurrences of that state.

Clocks are physical devices and thus, according to QGD, are made of molecules, which are made of atoms which are composed of particles; all of which are ultimately made of bounded *preons*⁽⁺⁾.

From the axioms of QGD, we find that the magnitude of the momentum vector of a *preon*⁽⁺⁾ is fundamental and invariable. The momentum vector is denoted by \vec{c} the momentum is $\|\vec{c}\| = c$.

We have shown that the momentum vector of a structure is given by $\vec{P}_a = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$ and its speed

by $v_a = \frac{\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|}{m_a}$. From these equations, it follows that the maximum possible speed of an object

a corresponds to the state at which all of its component *preons*⁽⁺⁾ move in the same direction.

In such case we have $\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c$ and $v_a = \frac{m_a c}{m_a} = c$. Note here that $\sum_{i=1}^{m_a} \|\vec{c}_i\|$

corresponds to the energy of a so the maximum speed of an object can also be defined as the state at which its momentum is equal to its energy.

From the above we see that the speed of an object must be between 0 and c while all its component *preons*⁽⁺⁾ move at the fundamental speed of c .

Now whatever speed a clock may travel, the speed of its *preons*⁽⁺⁾ components is always equal to c . And since a clock's inner mechanisms which produce changes in states depends fundamentally on the interactions and motion of its component *preons*⁽⁺⁾, the rate at which any mechanism causing a given periodic state must be limited by the clock's slowest inner motion; the transversal speed of its component *preons*⁽⁺⁾.

Simple vector calculus shows that the transversal speed of bound *preons*⁽⁺⁾ is given by $\sqrt{c^2 - v_a^2}$ where v_a is the speed at which a clock a travels. It follows that the number of recurrences of a state, denoted t for ticks of a clock, produced over a given reference distance d_{ref} is proportional to the transversal speed of component *preons*⁽⁺⁾, that is

$\frac{\Delta t}{d_{ref}} \propto \sqrt{c^2 - v_a^2}$. As the speed at which a clock travels increases, the rate at which it produces

ticks slows down and becomes 0 when its speed reaches c .

We have thus explained the observed slowing down of periodic systems without using the concepts of time or time dilation.

The predictions of special relativity in regard to the slowing down of clocks (or any physical system whether periodic or not, or biological in the case of the twin paradox) are in agreement with QGD however, the QGD explanation is based on fundamental physical aspects of reality. Also, since according to QGD, mass, momentum, energy and speed are intrinsic properties of matter, their values are independent of any frame of reference, avoiding the paradoxes, contradictions and complications associated with frames of reference.

However, though both QGD and special relativity predict the speed dependency of the rates of clocks, there are important differences in their explanation of the phenomenon and the quantitative changes in rate. While for special relativity the effect is caused by a slowing down of time, QGD explains that it is a slowing down of the mechanisms clocks themselves.

If Δt and $\Delta t'$ are the number of ticks counted by two identical clocks counted travelling respectively at speeds v_a and v'_a over the same distance d_{ref} then QGD predicts that

$$\Delta t' = \Delta t \frac{\sqrt{c^2 - v_a'^2}}{\sqrt{c^2 - v_a^2}} = \Delta t \frac{\sqrt{1 - \frac{v_a'^2}{c^2}}}{\sqrt{1 - \frac{v_a^2}{c^2}}}.$$

The speeds in the above equation are absolute so cannot be directly compared to special relativity's equation for time dilation which is dependent on the speed of the one clock relative to that of the other. However, the special relativity equation can be derived by substituting for v_a the speed of the second clock relative to the first clock v , then v'_a must be the speed of the second clock relative to itself, that is $v'_a = 0$, substituting in the equation above we get

$$\Delta t' = \frac{\Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} \text{ which the special relativity equation describing time dilation.}$$

Then using the derivations $\Delta x' = v \Delta t' = \frac{v \Delta t}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{x_2 - x_1}{\sqrt{1 - \frac{v^2}{c^2}}}$, $y' = y$ and $z' = z$, we can easily

derive the relation between two inertial frames of reference.

The Relation between Gravity and the Rates of Clocks

We know that $v_a = \frac{\|\vec{P}_a\|}{m_a}$ then $\frac{\Delta t}{d_{ref}} \propto \sqrt{c^2 - v_a^2} = \sqrt{c^2 - \left(\frac{\|\vec{P}_a\|}{m_a}\right)^2}$. We have also shown that gravity

affects the orientation of the component $preons^{(+)}$ of structure so that $\Delta\vec{P}_a = \Delta G(a;b)$ and

$\Delta\vec{v}_a = \frac{\Delta\vec{G}(a;b)}{m_a}$, and since $v'_a = \left\| \vec{v}_a + \frac{\Delta\vec{G}(a;b)}{m_a} \right\|$ in order to predict the effect of gravity on

the rates of clocks, all we need to do is substitute the appropriate value in $\Delta t' = \Delta t \frac{\sqrt{c^2 - v_a'^2}}{\sqrt{c^2 - v_a^2}}$

$$\text{and we get } \Delta t' = \Delta t \frac{\sqrt{c^2 - \left\| \vec{v}_a + \frac{\Delta\vec{G}(a;b)}{m_a} \right\|^2}}{\sqrt{c^2 - v_a^2}} = \Delta t \frac{\sqrt{1 - \frac{\left\| \vec{v}_a + \frac{\Delta\vec{G}(a;b)}{m_a} \right\|^2}{c^2}}}{\sqrt{1 - \frac{v_a^2}{c^2}}}$$

And if $\Delta\vec{G}(a;b) = \vec{0}$ then the equation is reduced to $\Delta t' = \Delta t$.

As we can see, the greater the gravitational interaction between a clock and a body, the slower will be its rate of recurrence of a given periodic state. This prediction is also in agreement with general relativity's prediction of the slowing down of clocks by gravity.

Predictions

QGD is in agreement with special relativity and general relativity's predictions of the slowing down of clocks but it differs in its understanding of time. Time for the QGD being a relational concept is necessary to relate the states of dynamical systems to the states of reference dynamical systems that are clocks. Clocks are shown not to be measuring devices but counting devices which mark the recurrences of a particular state of a periodic system chosen as reference. So if clocks are understood to measure time, then time is simply the number of times a given change in state occurs over a distance. It is not physical quantity.

We have shown that the slowing down of clocks resulting from increases in speed or the effect gravity is explained not as a slowing down of time, but as a slowing down of their intrinsic mechanisms.

The effects of time dilation predicted by special relativity and general relativity are both described

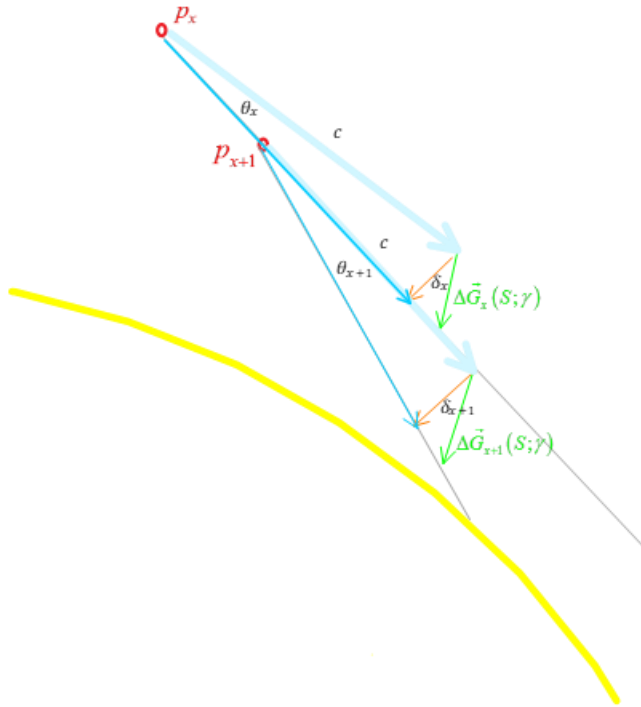
by $\Delta t' = \Delta t \frac{\sqrt{c^2 - \left\| \vec{v}_a + \frac{\Delta \vec{G}(a;b)}{m_a} \right\|^2}}{\sqrt{c^2 - v_a^2}}$ since this equation takes into account both the effect of

the speed and gravity on a clock. Thus, if QGD is correct, the predictions of SR and GR are approximations of particular solutions of the QGD equation.

Although both general relativity and QGD's qualitatively predict changes in the speed of clocks subjected to variations in the magnitude of the gravity effect, their predictions quantitatively differ. There is hope that, in the next few years, experiments such as [Atacama Large Millimeter/submillimeter Array](#) in Chile will discover pulsars moving in proximity to the supermassive black hole predicted to exist at the center of our galaxy (SGR A). The predictions of general relativity would then be tested against variations of the rate at which pulsars emit pulses as they are subjected to the intense gravity of the black hole. QGD makes distinct predictions which could also be tested against the same measurements.

Bending of light

The introduction of time delays on the effect of gravity via the second law of motion is



incompatible with Newtonian gravity which is instantaneous. This causes of the discrepancies between the Newtonian based predictions of the bending of light and observations.

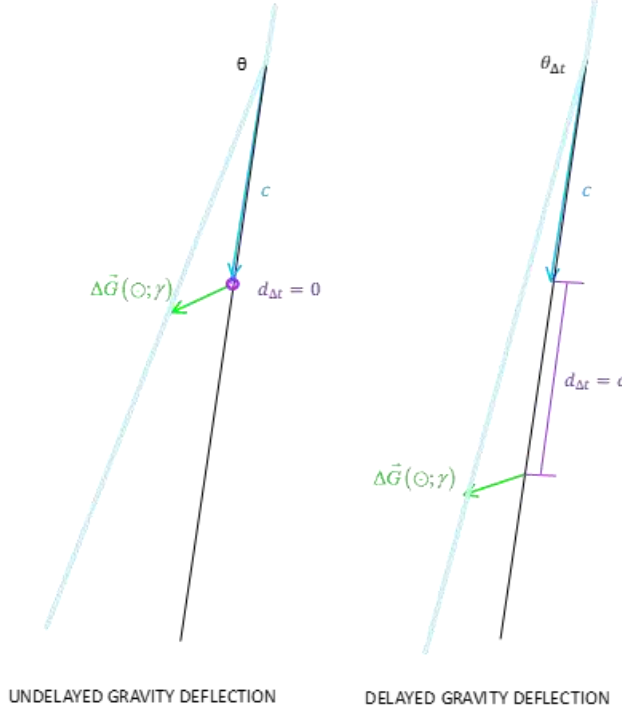
According to our minimal axiom set, photons are composed of *preons*⁽⁺⁾. It follows that photons interact gravitationally as do all other material body. Applying our equation for gravity to the trajectory of a photon coming into proximity to the sun ☉ we find that a photon γ changes direction at a position p_i by an angle

$$\theta_i \quad \text{given by} \quad \theta_i = \frac{\left\| \Delta \vec{G}(\odot; \gamma) \right\| \cos \delta_i}{2\pi c} \quad \text{where } \delta_i$$

is the angle between the vector $\Delta \vec{G}_{p_{i-1} \rightarrow p_i}(S; \gamma)$ and the

perpendicular to the vector \vec{P}_γ . The total angle of deflection θ of a photon is then

$$\theta = \sum_{-i}^i \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; \gamma) \cos \delta_i \right\|}{2\pi c}$$
 . The acceleration towards the sun expressed as units of distance per units of time. At the speed c this corresponds to a displacement of the vector $\frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; \gamma)$ equal to the distance travelled by a photon in one second or c units of distance (see figure 1 and 2).



Since $\theta_i = \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; \gamma) \right\| \cos \delta_i}{2\pi c}$ for non-delayed gravity and $\theta_{\Delta t} = \frac{\left\| \Delta \vec{G}(\odot; \gamma) \right\| \cos \delta}{2\pi * 2c}$ for time delayed gravity then $\theta_i = \frac{\theta_{\Delta t}}{2}$ and

$$\theta = \sum_{-i}^i \frac{\left\| \frac{\vec{G}}{p_i N}(\odot; \gamma) \right\| \cos \delta}{2\pi c} = 2\theta_{\Delta t}.$$

Non-delayed gravity predicts an angle of deflection θ that is exactly twice the angle $\theta_{\Delta t}$ predicted by time delayed Newtonian gravity. Hence, our prediction is in agreement with general relativity and

observations. That is for $\theta_{\Delta t} = .875''$ we get $\theta = 1.75''$.

Precession of the Perihelion of Mercury

The time dependency introduced when Newton's second law of motion also causes errors in Newtonian mechanics predictions of the motion of planets which causes the discrepancy between the predicted position of the perihelion of Mercury and its observed precession. The general

equation for the angle of deviation due to gravity is $\theta = \sum_{-i}^i \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(a; b) \right\| \cos \delta_i}{2\pi \left\| \vec{P}_b \right\|}$ so the angle

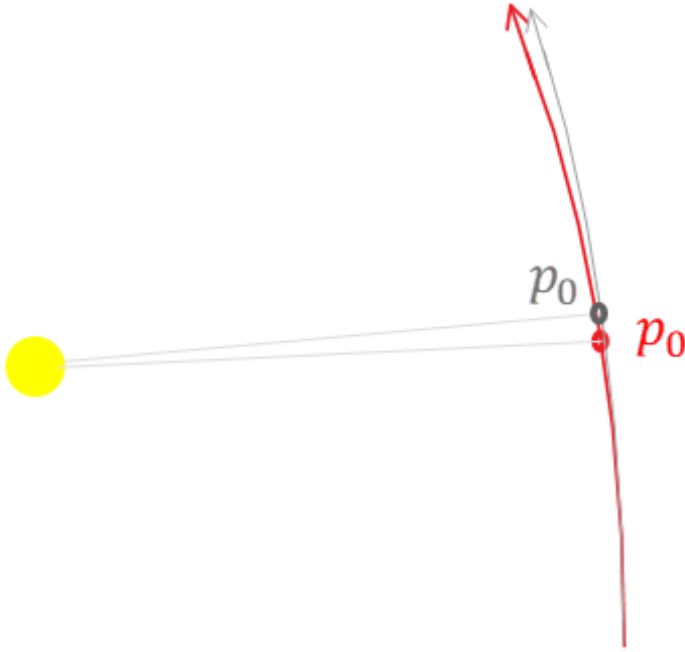
of non-delayed gravitational deflection of Mercury from its momentum vector at a given position

is $\theta = \sum_{-i}^i \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left\| \vec{P}_b \right\|}$. The angle for delayed gravity corresponds is obtained after a

displacement of the gravity vector equal to $\left\| \vec{v}_b \right\| \Delta t$ that is: $\theta_{\Delta t} = \sum_{-i}^i \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left(\left\| \vec{P}_b \right\| + \left\| \vec{v}_b \right\| \Delta t \right)}$.

Therefore, the angle of gravitational deflection for non-delayed gravity is greater from a given position p_x than for delayed gravity. The difference between θ and $\theta_{\Delta t}$ is the cause of the discrepancy between observations of the position the perihelion and that predicted by Newtonian mechanics. So in order to correctly prediction the precession of the perihelion of Mercury, we need to reduce the effect of the time delays as much as possible. We can do so by making the interval Δt as small as possible. For a given position we have

$$\lim_{\Delta t_i \rightarrow 0} \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left(\left\| \vec{P}_b \right\| + \left\| \vec{v}_b \right\| \Delta t_i \right)} = \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left\| \vec{P}_b \right\|}.$$

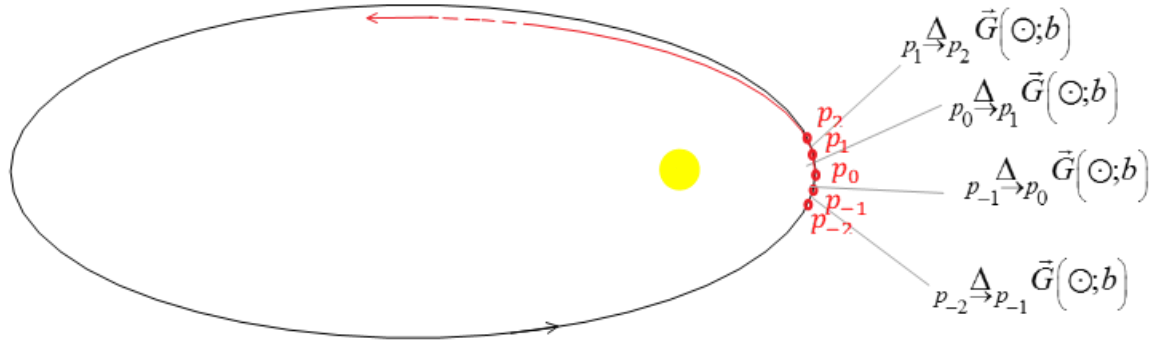


And using the relation $\frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \approx \vec{G}(\odot; b)$ where $\vec{G}(\odot; b) \Delta t$ is the Newtonian gravity at a position p_i allows us to work in conventional units since

$$\lim_{\Delta t_i \rightarrow 0} \frac{\left\| \vec{G}(\odot; b) \right\| \Delta t_{i-1} \cos \delta_i}{2\pi \left(\left\| \vec{P}_b \right\| + \left\| \vec{v}_b \right\| \Delta t_i \right)} = \frac{\left\| \frac{\Delta}{p_{i-1} \rightarrow p_i} \vec{G}(\odot; b) \right\| \cos \delta_i}{2\pi \left\| \vec{P}_b \right\|}.$$

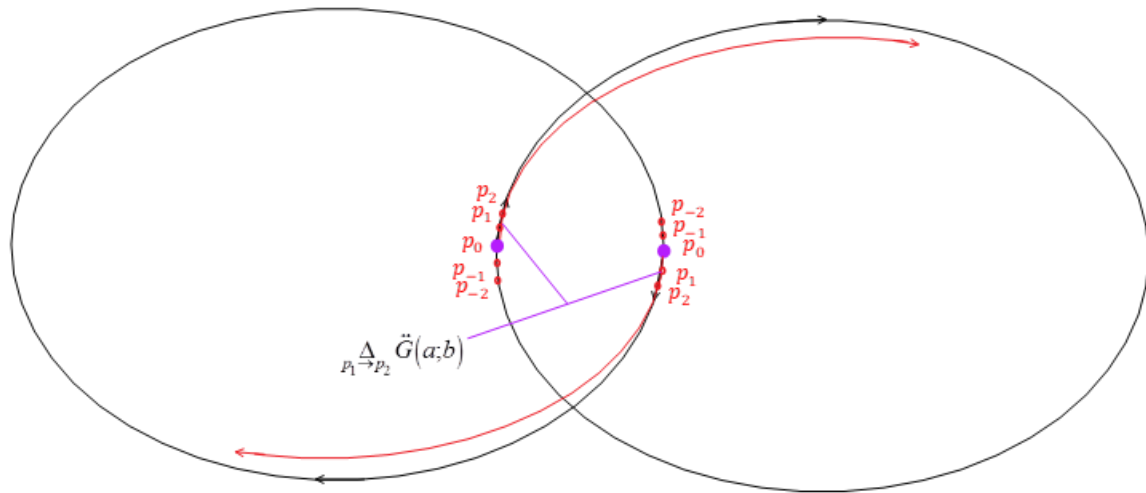
The angle of precession of the perihelion may then be obtained from initial position p_0 (in grey in the figure on the left) at a perihelion by calculating the position of the next perihelion (in red).

The figure below compares the non-delayed gravity prediction for a single orbit of Mercury (in red) in red to the prediction from Newtonian mechanics delayed gravity.



Orbital Decay of Binary Systems

The mechanisms using which we described and explained the precession of the perihelion of Mercury in the preceding section also predicts the precession of binary systems. Therefore we will not repeat the explanation here. Suffice to say all systems of gravitationally interacting systems are governed by the same laws and described by the same equations. QGD thus explains that the observed orbital decay such as that of the Hulse-Taylor system is not due to loss of energy emitted

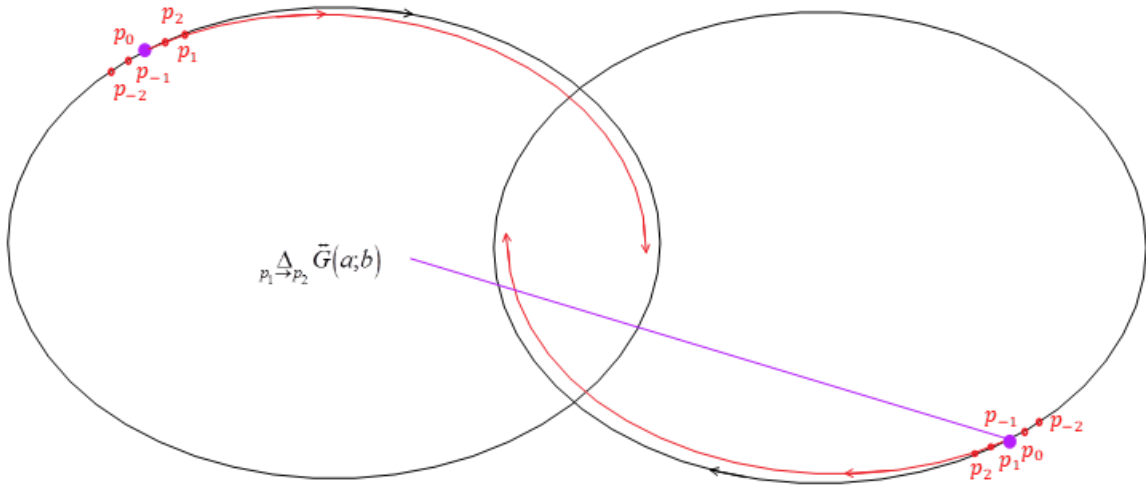


as gravitational waves, but increase in the momentum towards of each body towards the other due to gravitational acceleration. As we have explained earlier, gravitational acceleration results from the reorientation of the trajectories of the component vectors of the bodies and such an increase in momentum does not change the number of component *preons*⁽⁺⁾, hence has no effect on the mass or energy of the bodies. As massive bodies such as black holes spiral approach, they speed approach that of the speed of light so that their momentum approach their energy,

that is $\left\| \sum_{i=1}^{m_a} \vec{c}_i \right\| \rightarrow \sum_{i=1}^{m_a} \|\vec{c}_i\|$. Momentum is not conserved during gravitational acceleration but energy is. Therefore, there is no loss of energy in the process of coalescence of massive bodies. The mass and energy of resulting from the coalescence will be $m_{a+b} = m_a + m_b$, $E_{a+b} = E_a + E_b$ and $\vec{P}_{a+b} = \sum_{i=1}^{m_a} \vec{c}_i + \sum_{i=1}^{m_b} \vec{c}_i$. The resulting black hole (in the case of black hole merger) will spin at a speed equal to the speed of light.

The two figures illustrate how the QGD predictions (in red) diverge from that of Newtonian mechanics (in black).

The figure below extrapolates the orbital decay over the large number of orbits. As we see, the orbital decay will eventually lead to a collision of the two stars.



About the Relation Between Mass and Energy

As we have seen, the energy of a particle or structure is given by $E_a = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c$. Though similar in form to Einstein's equivalence equation, QGD's does not represent an equivalence but a proportionality relation between energy, mass and c which though numerically equal to c , the speed of light, here represents the intrinsic momentum of $preons^{(+)}$. This description of energy explains and provides the fundamental grounds for the principle of conservation of energy.

According to QGD's interpretation, when a body is accelerated by gravity, its mass and energy are both conserved. What changes is the net orientation of its $preons^{(+)}$ components. Hence, the

object's momentum, given as we have seen by $\|\vec{P}_a\| = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$, changes.

Applied to nuclear reactions, for example, we find that no mass is actually lost from its conversion to pure energy (there is no such thing as pure energy according to QGD). If the QGD prediction that photons have mass, a prediction that may be confirmed by deflection of light from the self-lensing binary systems, then the amount of mass that appears to have been converted to energy is exactly equal to the total mass of photons emitted as a result of the reaction. The so-called pure energy is actually the total momentum of the emitted photons. That is:

$$m = \sum_{i=1}^n m_{\gamma_i} \text{ and } E = \sum_{i=1}^n m_{\gamma_i} c \text{ where } m \text{ is the mass of the photons resulting from the reaction and } E, \text{ the momentum carried by the photons.}$$

The reader will note that since the momentum

vectors of the *preons*⁽⁺⁾ of photons are parallel to each other then $\left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\| = \sum_{i=1}^{m_\gamma} \|\vec{c}_i\|$, that is

momentum and the energy of a photon are numerically equal. However, it is important to keep in mind that though they can be numerically equivalent, momentum and energy are two distinct intrinsic properties.

The production of photons alone does not account for the total production of heat. Consider the nuclear reaction within a system S_1 containing n_1 particles resulting in S_2 , which contains n_2 particles (including the n photons produced by the reaction). Following QGD's axioms, we find

that the heat of S_1 and S_2 are respectively given by $heat_{S_1} = \sum_{i=1}^{n_1} \|\vec{P}_i\|$ and

$$heat_{S_2} = \sum_{j=1}^{n_2} \|\vec{P}_j\| < \sum_{j=1}^n m_{\gamma_j} c.$$

The temperatures of S_1 and S_2 , immediately after the reaction, before the volume S_2 expands

$$\text{are respectively } temp_{S_1} = \frac{\sum_{i=1}^{n_1} \|\vec{P}_i\|}{Vol_{S_1}} \text{ and } temp_{S_2} = \frac{\sum_{j=1}^{n_2} \|\vec{P}_j\|}{Vol_{S_2}} \text{ where } Vol_{S_1} \text{ is the volume of } S_1.$$

Implications

In its applications, the QGD equation relating energy, mass and the speed of light is similar to Einstein's equation. However, the two equations differ in some essential ways. The most obvious is in their interpretation of the physical meaning of the equal sign relating the left and right expressions of the equation. For QGD, the equal sign expresses a proportionality relation between energy and mass while Einstein's equation represents an equivalence relation.

Also, the equivalence interpretation of Einstein's equation implies the existence of pure energy and pure mass. QGD's axioms imply that mass and energy are distinct intrinsic properties of *preons*⁽⁺⁾ hence inseparable.

QGD's fundamental definitions of mass, energy, momentum and speed that can be applied to all systems regardless of scale.

Other Consequences of QGD's Gravitational Interaction Equation

Dark Photons and the CMBR

Another implication of the axiom set of QGD which will be discussed in detail in the cosmology section of this book follows what the initial state of the universe it predicts. In its initial state, the only matter was in the form of free *preons*⁽⁺⁾ which were isotropically distributed throughout quantum-geometrical space.

During the isotropic state, *preons*⁽⁺⁾, as a consequence of the attractive force acting between them and over long travelling distances, started to form the simplest of all particles; low mass photons and neutrinos. And because *preons*⁽⁺⁾ were distributed isotropically, so was the distribution of these particles.

From the description of the laws of momentum, assuming that variations in gravity and the electromagnetic are negligible, the permitted change in momentum permitted for an electron must obey the relation $\|\Delta\vec{P}_{e^-}\| = xm_{e^-}$ ⁹. This means that photons γ (or neutrinos) whose momentum $\|\vec{P}_{\gamma}\| < m_{e^-}$ are undetectable and therefore dark (we'll refer to them as dark photons).

If QGD's is correct, then the first detectable photons, photons for which $\|\vec{P}_{\gamma}\| \geq m_{e^-}$, have been first observed in 1964 by Arno Penzias and Robert Wilson and correspond to the [cosmic microwave background radiation](#) (CMBR). The observed isotropy of the CMBR then follows naturally from the initial isotropic state of the universe.

Effect Attributed to Dark Matter

We will see in the section titled [QGD Cosmology](#) that the universe's initial state was that contained nothing but quantum-geometrical space and free *preons*⁽⁺⁾ which were homogenously distributed in space.

Under the effect of gravity, free *preons*⁽⁺⁾ formed large structures. The effect we attribute to dark matter is the interactions between light and material structures with regions of space in which free *preons*⁽⁺⁾ have condensed and which we call now dark matter halos.

⁹ The general equation is $\|\Delta\vec{P}_{e^-}\| = xm_{e^-} + \|\Delta\vec{G} + \Delta\vec{\Theta}\|$ where \vec{G} and $\vec{\Theta}$ are respectively the

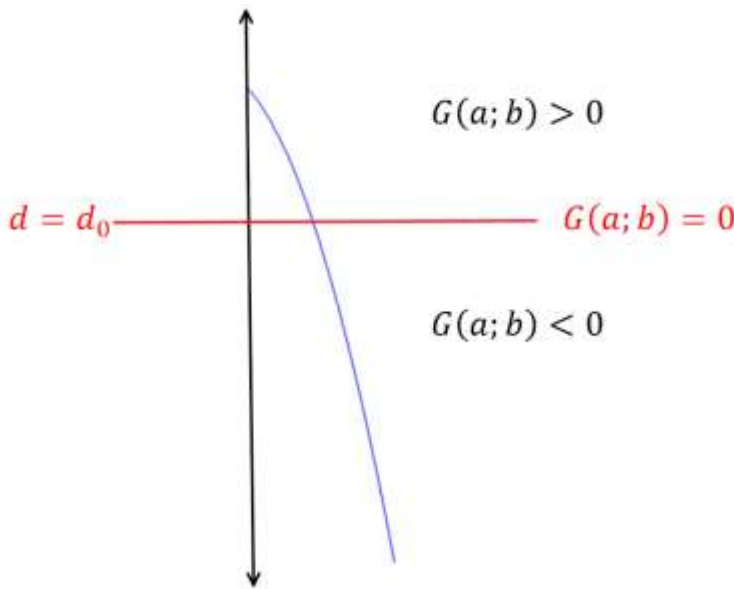
gravitational and electromagnetic effects acting on e^- . The general equation will be discussed and applied in the section [Preonics \(foundation of optics\)](#).

Effect Attributed to Dark Energy

QGD's equation for gravity predicts both attractive gravitational interaction, $G(a;b) > 0$ when $k > \frac{d^2 + d}{2}$, and repulsive gravitational interaction, $G(a;b) < 0$ when $k < \frac{d^2 + d}{2}$. For

distances shorter than the threshold distance d_Λ where $k = \frac{d^2 + d}{2}$, where $G(a;b) = 0$ regardless of m_a and m_b , p-gravity overcomes n-gravity, but at distances beyond d_Λ , gravity is repulsive and increases proportionally to the square of the distance. And acceleration being proportional to the derivative of gravity, QGD predicts a linear increase in acceleration as a function of distance.

QGD equation for gravity's prediction of repulsive gravity beyond the threshold distance may explain the acceleration we attribute to dark energy.



attribute to dark energy.

We have shown that:

1. QGD's law of gravity predicts that at very short distances the number of p-gravity interactions, hence the attractive gravity, is over a hundred orders of magnitude greater than gravity at large scale.
2. QGD law of gravity describes gravity at scales at which we apply Newtonian gravity, and
3. That at very large scale the equation accounts for the effect we

It follows that for distances between material structures greater than the threshold distance d_Λ , and assuming there is no matter in the space that separates them, the gravitational interaction will be repulsive and proportional to the square of the distance beyond d_Λ , resulting in a gravitational acceleration proportional the distance.

We have also shown that the effect we attribute to dark matter can be the gravitational effect of free *preons*⁽⁺⁾ over large regions of space.

Einstein's Equivalence Principle

According to QGD, there is only one definition of mass: the intrinsic mass of an object being simply the number of *preons*⁽⁺⁾ it contains. The intrinsic mass determines not only the effect of gravity but all non-gravitational effect.

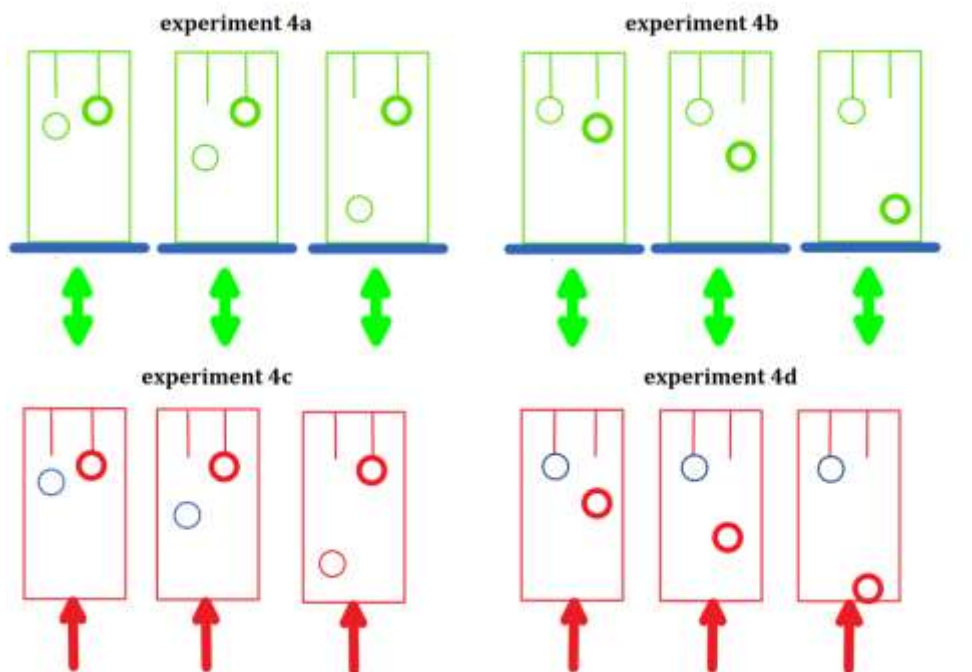
The gravitational mass is that property which determines the magnitude of gravitational acceleration while the inertial mass determines the magnitude of non-gravitational acceleration. It is important in describing a dynamic system that we understand that the distinction made between the gravitational and inertial masses are distinctions between gravitational and non-gravitational effects. Doing so, we will show that the intrinsic mass determines both gravitational and non-gravitational effects and that these effects are very distinct, thus distinguishable.

The acceleration of an object is given by $\Delta v_a = \frac{\|\Delta \vec{P}_a\|}{m_a}$ where $\|\Delta \vec{P}_a\| = \|\Delta \vec{G}\|$ for gravitational acceleration and $\|\Delta \vec{P}_a\| = \|\vec{F}\|$ for non-gravitational force \vec{F} imparting momentum to a . From

$$\Delta v_a = \frac{\|\Delta \vec{G}\|}{m_a} = \frac{1}{m_a} m_a m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right) = m_b \left(\left(k - \frac{d_1^2 + d_1}{2} \right) - \left(k - \frac{d_2^2 + d_2}{2} \right) \right)$$

we know that gravitational acceleration is independent of the mass of the accelerated body, while

$\Delta v_a = \frac{\|\vec{F}\|}{m_a}$ tells us that non-gravitational acceleration is inversely proportional to the mass of the accelerated body. Let us consider the experiments represented in the figure below which based on Einstein's famous thought experiment.



The green rectangles represent a room at rest relative to Earth's gravitational field.

The Earth and green room dynamics is described by the equation $\vec{v}_{\boxed{g}} = \frac{\vec{P}_{\boxed{g}}}{m_{\boxed{g}}} = \frac{\vec{P}_{\boxed{E}}}{m_{\boxed{E}}} = \vec{v}_{\boxed{E}}$

where \boxed{g} represents the green room and \boxed{E} the Earth. Applying the laws of momentum [discussed earlier](#), we know that green room and the Earth are moving at the same speed hence, since $(v_{\boxed{g}} - v_{\boxed{E}})m_{\boxed{g}} = 0$ and $(v_{\boxed{E}} - v_{\boxed{g}})m_{\boxed{E}} = 0$ there is no momentum transfer between the Earth and the green room, consequently no non-gravitational acceleration. And since there is no change in distance between \boxed{g} and \boxed{E} , there is no variation in the gravity, so no gravitational acceleration either.

The red room is in region of space where the effect of gravity is negligible. A non-gravitational force imparts momentum \vec{F} to the red room from the floor up.

Einstein's thought experiment assumes that it is possible to apply a force which will accelerate the red room so that, to an observer within the room, the acceleration will be indistinguishable from that of gravity. That is, he assumes that $\vec{F} = \Delta\vec{G}$.

Before going into a full description of the experiment, we need to keep in mind the distinctions between gravitational acceleration and non-gravitational acceleration. For one, gravitational acceleration of body is independent of its mass while non-gravitational acceleration of a body is inversely proportional to its mass. That is: $\Delta\vec{v}_a = \frac{(\vec{v}_F - \vec{v}_a)m_{\vec{F}}}{m_a}$ where \vec{v}_F is the speed of the

particles carrying the momentum \vec{F} (in the case of a rocket engine, this is the speed of the molecules of gas produced by the engine which interact with the room) and v_a the speed of the room. It follows that we can set $\vec{F} = \Delta\vec{G}$ for a given m_a but for an object of mass $m_b \neq m_a$, we can have $\vec{F} = \Delta\vec{G}$ but $\vec{F} \neq \vec{F}'$ and $\Delta\vec{v}_a = \frac{(\vec{v}_F - \vec{v}_a)m_{\vec{F}}}{m_a} \neq \frac{(\vec{v}_F - \vec{v}_b)m_{\vec{F}}}{m_b} = \Delta\vec{v}_b$. Which means

that, to maintain an acceleration equivalent to gravitational acceleration, \vec{F} must be adjusted to take into account the mass of the accelerated to compensate for its speed since the imparted momentum of a rocket engine (or any other form of propulsion) decreases as the speed increases.

Returning to experiment 4, the green and red rooms will have the same mass and composition. In each room, there will be a set of two spheres of mass m_a and m_b where $m_a < m_b$. In the rooms initial states, the spheres are suspended from rods fixed to the ceilings. The spheres can be released on command. In each of the room is an observer that is cut off from the outside world.

They have no clue as to which of the two rooms they are in. The observers however, being experimental physicists, are trusted to measure the accelerations of the spheres in the two experiments and see if they can determine whether the room each is in is at rest in a gravitational field or uniformly accelerated.

In the first experiment, the spheres with mass m_a will be dropped in each room. In the second experiment, from the same initial state, spheres with mass m_b will be dropped.

The green room observer finds that both spheres have the same rate of acceleration relative to the room despite having different masses. He finds this to be consistent with gravitational acceleration but cannot exclude based on these two experiments alone that he may be in a uniformly accelerated room.

The red room observer however finds that rate of acceleration of the a sphere is lower than the rate of acceleration of the more massive b sphere. His observations of the accelerations of the spheres being inconsistent with gravitational acceleration he must conclude that the room is accelerated by an external non-gravitational force \vec{F} .

Furthermore, being a physicist, the red room observer knows that at the moment a sphere is released, the momentum imparted by \vec{F} is no longer transferred to the sphere. The sphere stops accelerating instantly and will move at the speed it had at the moment of its release. Therefore, it is the room that is accelerated and not the sphere. The acceleration of the red room in its initial

sate is $\Delta v_{[r]} = \frac{\|\Delta \vec{F}\|}{m_{[r]} + m_a + m_b}$. At the moment the a sphere is released, there is a sudden

change in the rate of acceleration of the room given by $\Delta \Delta v'_{[r]} = \frac{\|\vec{F}\|}{m_{[r]} + m_b} - \frac{\|\vec{F}\|}{m_{[r]} + m_a + m_b}$. The

change the rate of acceleration after the release of sphere b is

$\Delta \Delta v'_{[r]} = \frac{\|\vec{F}\|}{m_{[r]} + m_a} - \frac{\|\vec{F}\|}{m_{[r]} + m_a + m_b}$. The higher variation the in the rate of acceleration after the

release of b is seen from within the room as a larger acceleration of b relative to the room.

So, it appears that observers can easily distinguish between being in a room at rest in a gravitational field from being in a uniformly accelerated room away from any significant gravitational field. This appears to invalidate the weak equivalence principle. Being an experimental physicist, the observer in the red room requires confirmation of his observation. He decides to repeat the experiment. After all, one experiment is not enough, and one has to be able to reproduce the results before doing something so drastic as to refute the weak equivalence principle.

Again, the more massive sphere accelerates faster than the lighter sphere, but something is different. The acceleration rates of sphere *a* and sphere *b* in the second set of experiments are slower than the accelerations of the same spheres in the first set of experiments. After conducting a few more experiments he finds the observations to be consistent with $\Delta \vec{P}_{[r]} = (v_{\vec{F}} - v_{[r]}) m_{\vec{F}}$ and concludes that the momentum imparted by the non-gravitational force decreases as speed of the room increases which allows him to predict that the maximum possible speed the red room can achieve is $\vec{v}_{[r]} = \vec{v}_{\vec{F}}$ at which speed $\Delta \vec{P}_{[r]} = (v_{\vec{F}} - v_{[r]}) m_{\vec{F}} = 0$ and $\Delta v_{[r]} = \frac{\Delta \vec{P}_{[r]}}{m_{[r]}} = 0$.

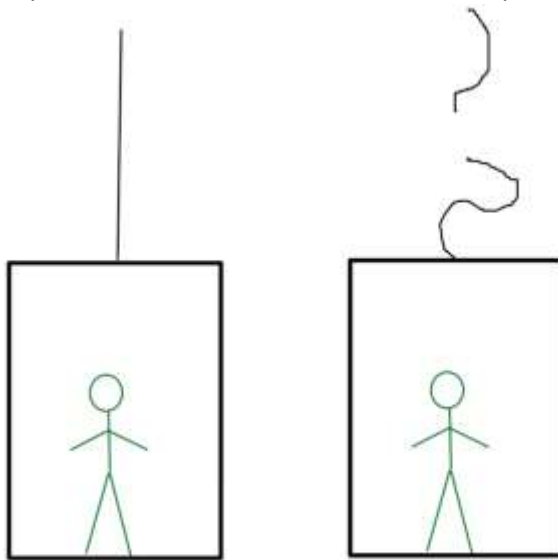
The above experiments confirm QGD predictions that:

- Gravitational acceleration and non-gravitational acceleration are not equivalent then
 - Einstein's equivalence principle is falsified
- The outcome of an experiment may be affected by the speed of the laboratory then
 - The strong equivalence principle is falsified

Note: The force acting on the red room being non-gravitational, its observer would feel an acceleration when one or both spheres are released. But the observer in the green room would feel no acceleration when one of both spheres are released. This makes it possible to distinguish between gravitational and non-gravitational acceleration within a room without instruments.

Weightlessness in Einstein's thought Experiment

Consider a man standing in an elevator when suddenly the elevator cable breaks. After the rupture of the cable the elevator and the passenger and elevator are in free fall and, as if gravity had been turned off, they are weightless.



There is, it seems, no acceleration; an interpretation that is supported by the fact that if we were to put an accelerometer on the floor of the elevator, it would measure no acceleration. In fact, an accelerometer alone in free fall measures no acceleration. In the absence of other forces (assumed to be inexistent for the experiment) zero acceleration implies that zero force and a logical interpretation would be that gravity is not a force. This interpretation leads to the idea that gravity is the effect of curvature of space-time.

Let us describe the dynamics of the elevator and its passenger from Einstein's thought experiment of 1907. If the elevator is at rest before the rupture of the cable, then the dynamics is

$$\vec{v}_{[g]} = \frac{\vec{P}_{[g]}}{m_{[g]}} = \frac{\vec{P}_{[E]}}{m_{[E]}} = \vec{v}_{[E]} \text{ where } [g] \text{ represents the elevator with the passenger and } [E]. \text{ In}$$

order to correctly describe the system, we need to use the intrinsic speed and momentum since the relative speed is misleading. Even though the speed of the passenger relative to the elevator is equal to zero, we know that it, along with the Earth, the solar system, and the entire galaxy, is speeding through space. Using conventional definitions of speed and momentum, which have null values, do not describe the system.

Before the cable ruptures

If the passenger were to jump in the elevator, that is, increase its speed by bending its legs and suddenly extending them, then, assuming that Δv_{pass} of extension from his the center of gravity,

$\Delta \vec{P}_{[E]} = \Delta v_{pass} m_{pass}$ and $\Delta \vec{P}_{pass} = -\Delta v_{pass} m_{pass}$. The momentum of the passenger after the jump is $\vec{P}'_{pass} = \vec{P}_{pass} - \Delta v_{pass} m_{pass}$ and its speed is $v'_{pass} = v_{pass} - \Delta v_{pass}$ where $-\Delta v_{pass}$ is the passenger's speed relative to the Earth.¹⁰

Now, applying the gravitational interaction equation, we know that after the jump the passenger

will lose momentum proportionally to ΔG , that is $\Delta \vec{v}_{pass} = \frac{\Delta \vec{P}_{pass} - \Delta \vec{G}}{m_{pass}}$ so that when

$\Delta \vec{G} = \Delta \vec{P}_{pass}$ the passenger speed will be back to its initial speed (zero relative to Earth) and the passenger will be gravitationally accelerated towards the Earth.

When the passenger lands back on the floor, the momentum of passenger will be

$\vec{P}''_{pass} = \vec{P}_{pass} + \Delta \vec{G}$ resulting in a [transfer of momentum](#) from the passenger to the Earth (mediated by the elevator) and equal to $\Delta \vec{G}$ and since $\Delta \vec{G} = \Delta \vec{P}_{pass}$ the initial state is and conserving the momentum of the system.

We can now focus our attention on the thought experiment 3.

After the cable ruptures

When the cable is ruptured, $\vec{H} = \vec{P}_{[g]}$, the force that prevented the elevator from accelerating towards the Earth and which is transmitted via the cable is cut off. The elevator and passenger

¹⁰ We ignore here the negligible acceleration of the Earth from the jump which is $\Delta v_{[E]} = \frac{\Delta v_{pass} m_{pass}}{m_{[E]}}$

will move at their initial speed towards the Earth that is $\vec{v}_{[g]} = \frac{\vec{P}_{[g]}}{m_{[g]}}$. What the passenger

perceives as weightlessness is correct. Since the weight is simply the measurement of \vec{H} , when the cable is cut off, \vec{H} is no longer imparted to the passenger and thus he is weightless. The removal of the effect of weight is not the removal gravity but the removal of the force that opposes gravity. There is increase in momentum, hence acceleration, which the passenger will be transferred to the Earth when the elevator hits the ground.

Since all components of an accelerometer are accelerated uniformly and at the same rate (see [universality of free fall](#)) it cannot measure gravitational acceleration. What an accelerometer measures is the effect of weight. That is: it measures \vec{H} . And \vec{H} ceases to be transferred to the elevator and content after rupture of the cable so it will measure zero weight.

However, though the accelerometer (denoted *acc* below) cannot measure gravitational acceleration, it can inform of its momentum, its gravitational acceleration and its speed if we record and correctly interpret the measurement α it makes before release, the null reading during free fall, the measurement α' at impact and α'' after impact since:

$$\vec{H} = \vec{P}_{acc} \rightarrow \vec{P}_{acc} = \alpha,$$

$$\Delta G = \alpha' - \alpha'' \text{ and } \Delta v_{acc} = \frac{\Delta G}{m_{acc}}, \text{ and}$$

$$\vec{H} = \vec{P}_{acc} \rightarrow \vec{P}_{acc} = \Delta \alpha''.$$

If there were a second elevator cabin in space and moving at uniform speed, as describe in another one of Einstein thought experiment, it would be in a state of weightlessness and without gravity, so that $\alpha = \alpha' = \alpha'' = 0$. That would allow an observer to easily distinguish the experience of being in a cabin in space from being in a cabin free falling in a gravitational field.

We have shown that though there is only one kind of [mass](#), the effects of gravity and non-gravitational force can never be equivalent. And even when cut off from the outside world, as is imagined in Einstein's thought experiments, observers can correctly describe and distinguish between the forces acting on their environment through experiments as long as measurements are made of the initial, transitory and final states of the experiments and a minimum of two distinct experiments are conducted for each measured property.

Gravitational Waves

QGD precludes the existence of gravitational waves so how can this be reconciled with the advanced LIGO observatory detections of signals that are consistent with gravitational waves

predicted from general relativity? How does QGD explain these signals if, as it predicts, there are no gravitational waves?

LIGO made detected several signals that were thought to be due to gravitational waves but only the detection of the event known as GW170817 had electromagnetic counterparts. This observation makes it possible to narrow down the possible explanations to one.

If QGD's theory of gravity is correct, then the observations of electromagnetic counterparts rather than confirming the existence of gravitational waves falsifies it. Or at the very least excludes the possibility that GW170817 is a gravitational signal. The question we must then answer is: What explains the signal?

It is important to keep in mind that any explanation we provide must be consistent with QGD's axiom set. The axiomatic approach adopted for QGD prohibits the introduction of ad hoc explanations in the theory.

First, since LIGO-VIRGO detected the GW170817 only 1.7 seconds before the detection of a gamma ray burst GRB170817, if the signal was generated by the same event we can assume that it must have travelled at the speed of light. Now, according to QGD, only $preons^{(+)}$, photons and neutrinos can travel at the speed of light. Since GW170817 is neither of the latter two we are left with only one possibility; GW170817 is caused by $preons^{(+)}$, specifically $preons^{(+)}$ resulting from the polarization of a large regions of the preonic field. The mechanism of polarization has been discussed in detail [here](#).

Secondly, the event produces a wave-like signal which increases in both frequency and amplitude. This is consistent with the polarization of the preonic field by a coalescing binary system.

As the stars of a binary system accelerate towards each other, they themselves become polarized. The polarization of the stars results from the polarization of the components $preons^{(+)}$ of the stars by the increasing gravitational interaction in accordance to the laws we derived in the section titled [Gravitational Interactions and Momentum](#).

The intensity of the polarization of the preonic field is by each one of the stars proportional to the size and density of the stars and its rotation speed.

For a binary system, the polarization of a neighboring region of the preonic field will vary as polarized stars pass through them. So the closer there orbit each other, the higher the orbital speed, the greater the frequency. And the greater their speed, the greater their polarization.

The frequency of the signal is the proportional rotation speed of the binary system $f = \frac{v_{\theta}}{\pi}$

As for the amplitude of the signal $\|\vec{P}_\Theta\|$ we have

$$\|\vec{P}_\Theta\| \propto \frac{\|\vec{P}_{b_1}\| dens_{b_1} dens_{p^{(+)}} \cos \delta + \|\vec{P}_{b_2}\| dens_{b_2} dens_{p^{(+)}} \cos(\delta + \pi)}{d} v_\theta \cos \theta$$

where v_s is the rotation speed of the system, δ is the angle of the star relative to the line of sight, θ is the inclination of the plane of rotation, d the distance of the observer, and $dens_{b_1}$ and $dens_{b_2}$ are the density of the stars b_1 and b_2 .

From the above, we can see that the signals detected by LIGO and VIRGO are consistent with both the prediction of general relativity and QGD, that is it could cause by gravitational waves or by preonic waves. Thus a prediction unique to QGD is necessary to determine which of the interpretations of the observations is correct.

Preonic waves are composed of polarized $preons^{(+)}$ just as magnetic fields are. It follows that if the signal is due to preonic waves, QGD predicts that it would cause fluctuations in the magnetic moment of a magnet and the signal formed by the fluctuations will mirror the signal detected by LIGO-VIRGO observatories or other gravitational wave detector. Testing the prediction requires high precision magnetic field sensors to monitor the fluctuations in the magnetic fields generated by reference magnets and simultaneously comparing them to signals detected by LIGO-VIRGO or future detectors.

Locality, Certainty and Simultaneity

Locality and Instantaneous Effects

Non-locality is based on the assumption that an event which affects a system cannot affect another system which is independent of it. Independent systems being defined as systems which are separated by a distance sufficiently large to prohibit one from influencing the other without violating the speed limit predicted by special relativity. But if gravity is instantaneous, then no system is truly independent which means that all systems are local and can affect each other instantaneously regardless of distance.

Under instantaneous interactions, the entire universe is local.

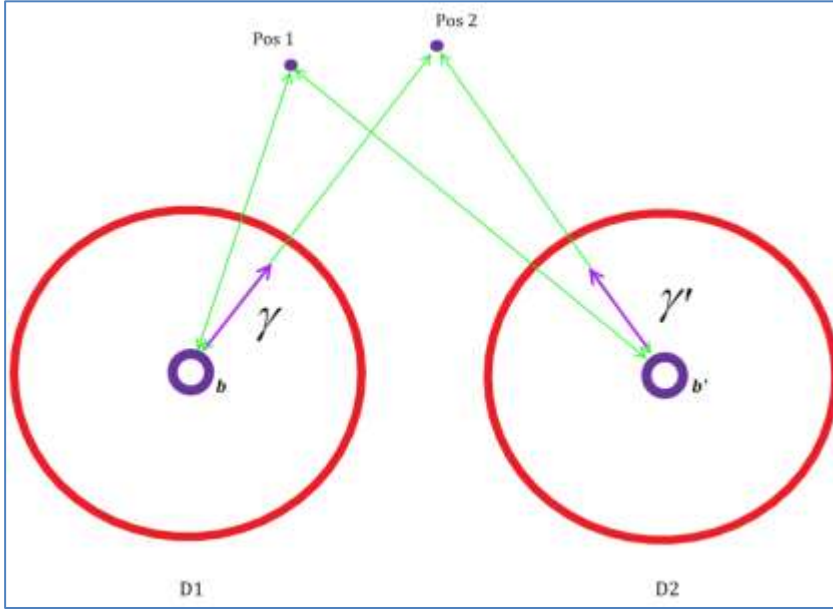
Currently, independent experiments which show correlations that cannot be accounted for by local hidden variables correlation are taken as evidence that reality is fundamentally non-local, hence are taken as evidence supporting quantum-entanglement. But if gravitational interactions and the electromagnetic effect of generation of magnetic fields are instantaneous, then any two experiments will influence each other instantaneously yet remain classical since they do so without violating locality since, as we have indicated earlier, the entire universe becomes local if these effects are instantaneous.

Instantaneity and the Uncertainty Principle

The uncertainty principle states that two conjugate properties cannot be known with certainty. The most common example being that of the properties of momentum and position. According to the Heisenberg's uncertainty principle, as the certainty of the measurement of momentum increases, the uncertainty of the position increases as well. This is described by the famous equation $\sigma_x \sigma_p \geq \frac{\hbar}{2}$ and thought to be inherent to wave-like systems. But if space is discrete (specifically quantum-geometrical as per QGD's axiom of discreteness of space), then the wave function provides only an approximation of the scattering of singularly corpuscular particles and the uncertainty principle is a consequence of quantum mechanics; not a fundamental reality in which space is discrete rather than continuous.

Position and Momentum of Particles (or Structures)

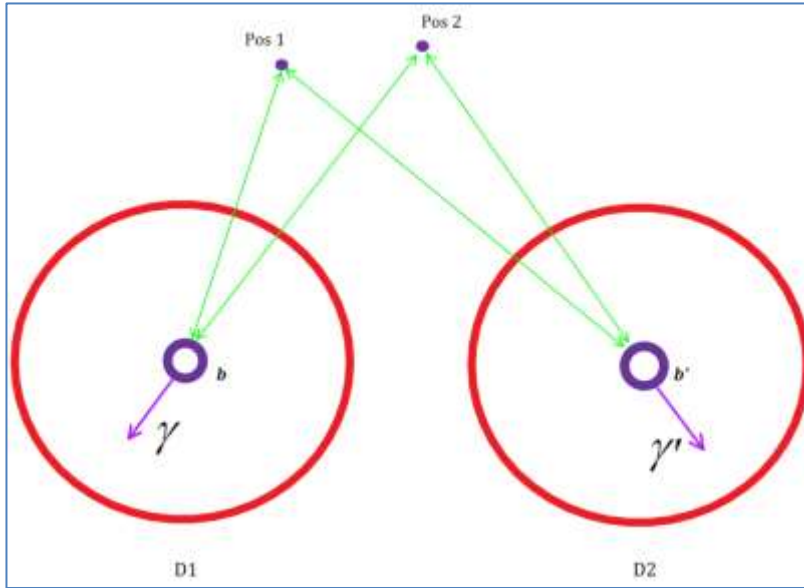
Consider a particle which momentum and position are unknown and two gravitational detectors as shown in figure 1. The red circles in the figure represent arrays of photon detectors which will detect and measure the photons energy and direction. At the core of the detectors are variable mass spherical structures b and b' (the mechanism by which the mass of the cores may be laser pulses or a form a induce decay of its structure).



According to QGD, when the position of a particle a (purple dots) changes position, $G(a;b)$ and $G(a;b')$, respectively the gravitational interactions between it and the cores b and b' at the center of the detectors $D1$ and $D2$ instantly change.

A consequence of space being discrete is that only changes in momentum which are

multiple of m_b units of momentum are allowed.¹¹ So, if $|\Delta G(a;b)| < m_b$ the change in the



gravitational interaction is insufficient to impart momentum of b . In order to satisfy the gravitational interaction equation

$$G(a;b) = m_a m_b k - \sum_{i=1}^{m_j} \frac{d_{i,j}^2 + d_{i,j}}{2}, \quad b \text{ and } b' \text{ must emit photons } \gamma \text{ and } \gamma' \text{ which momentum}$$

must exactly equal $\Delta G(a;b)$ and $\Delta G(a;b')$ units of momentum¹². That is: $\|\vec{P}_\gamma\| = |\Delta G(a;b)|$

¹¹ This explains why atomic electrons can only absorb photons of specific energy. QGD attributes the different absorption energies to minute variations in the masses of orbital electrons.

¹² A principle of conservation of momentum (induced momentum for gravity) comes into play here. If a change in the magnitude of the interaction between a and b is smaller than that which is required to

and $\|\vec{P}_{\gamma'}\| = |\Delta G(a; b')|$ where the directions of the momentum vectors \vec{P}_λ and $\vec{P}_{\gamma'}$ (purple arrows) coincide with $\vec{G}(a; b)$ and $\vec{G}(a; b')$.

By triangulation, the instantaneous position and distance of a can be found and depending on the distance and direction we can make the following interpretation:

1. If distance is such that $k > \frac{d^2 + d}{2}$ and \vec{P}_γ points towards a , then a is moving towards b ;
2. If $k > \frac{d^2 + d}{2}$ and \vec{P}_γ (or $\vec{P}_{\gamma'}$) points away from a then a is receding from b ;
3. If $k < \frac{d^2 + d}{2}$ and \vec{P}_λ points towards a , then a is receding from b ;
4. If $k < \frac{d^2 + d}{2}$ and \vec{P}_γ points away from a , then a is moving towards b .

The momentums (which for photons is equal to their energy) $\|\vec{P}_\gamma\|$ and $\|\vec{P}_{\gamma'}\|$ provides an exact measure of $\Delta G(a; b)$ and $\Delta G(a; b')$. Since m_b and $m_{b'}$ are known, we can resolve the gravitational interaction equation for m_a , hence obtain an exact value of its mass.

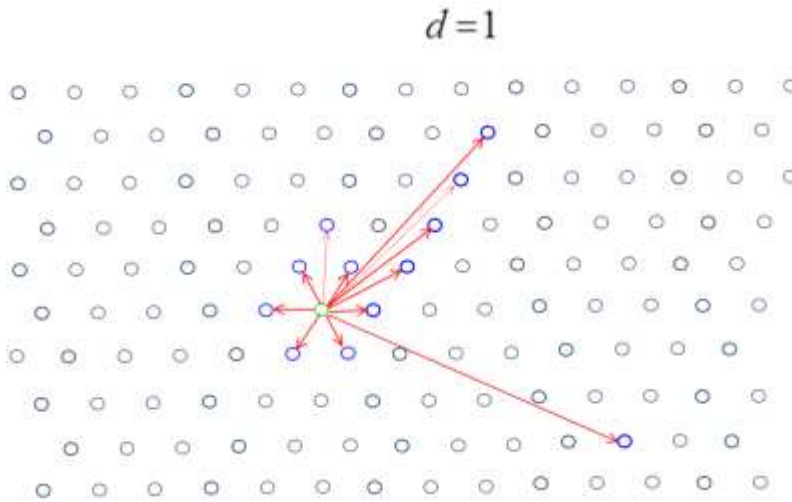
Thus a first measurement gives us the instantaneous position and mass of a .

A second measurement with give us a second position, hence the distance travelled between position 1 and position 2. This allows us to calculate speed $v_a = \frac{d_x}{d_{ref}} c$ were d_{ref} is the distance light would have travelled during the same interval. From QGD's definition of speed we know that $v_a = \frac{\|\vec{P}_a\|}{m_a}$ where \vec{P}_a is the momentum vector of a so that $\|\vec{P}_a\| = m_a v_a$. Therefore, a second measurement allows us to find simultaneously the position and momentum of a with certainty.

achieve the minimum change in momentum in one or both particles, then one or both must emit photons that will carry the would be change in momentum.

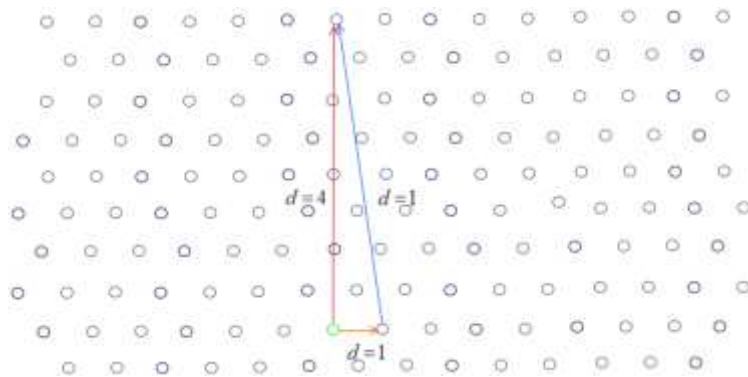
Interactions between Distant Experiments

If space is discrete as per QGD's axiom, then we know that there can be significant differences between the geometrical distance and the physical distance between any two positions in space. The physical distance between two particles, even when large, may be significantly reduced even by a small shift in their positions.



In the figure on the left, the geometrical distance may be associated with the lengths of the red arrows, while the physical distance, corresponds to the number of leaps necessary to move from an initial position (green circle) to a second position (blue circles).

As we can see, though the geometrical distances between the green position and the blue positions may vary greatly, the physical distance between them is the same and equal to one unit.



In the figure on the left, we see that at the fundamental scale, Pythagoras's theorem does not hold. How Euclidean space emerges at larger scales is explained in [here](#). If we assume the existence of a particle b positioned at the top vertex and particle a at the bottom left vertex (green circle). If a moves one position to the right to the bottom right vertex, the physical distance between a and b becomes four times smaller even though the geometrical distance increased. Such changes in physical distance will cause significant instantaneous changes in the gravitational interaction between the particles and additionally, if the particles are not electrically neutral, significant changes the magnetic field they generate.

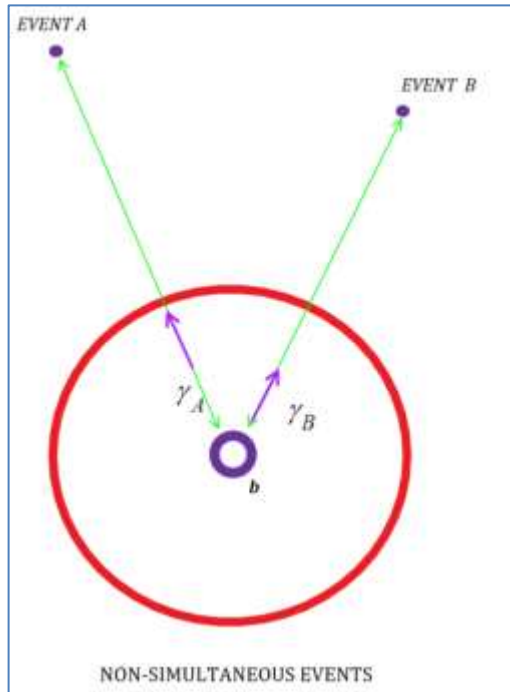
Since experiments use electronic components, they contain particles or structures a and b which are not electrically neutral. In such case, the change in the momentum of the magnetic field they generate can impart will be orders of magnitude greater than that of purely gravitational changes and photons emitted by b will have significantly greater energy.

Since experiments use electronic components, they contain particles or structures a and b which are not electrically neutral. In such case, the change in the momentum of the magnetic field they generate can impart will be orders of magnitude greater than that of purely gravitational changes and photons emitted by b will have significantly greater energy.

When in one experiment a particle is measured, it causes changes in the momentum of some of its component particles (changes in electrons within the electrical current which powers its

detectors for example), these changes are compounded and will cause components of a second experiment to emit photons instantly. Some of the photons produced within the second experiment will have energies in the range of the sensitivity of detectors.

The Notion of Simultaneity

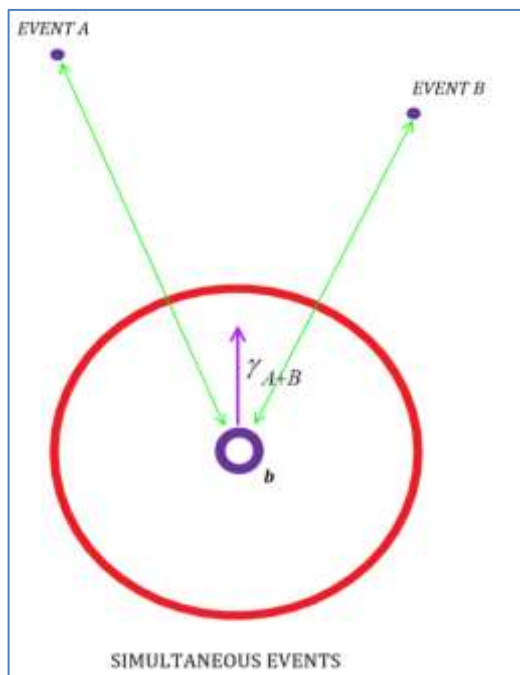


If gravity is instantaneous then all objects in the universe are local. That means that if an event affects an object anywhere in the universe, the gravitational interactions between that object and all other objects in the universe regardless the distances that separate them will be affected instantly.

An event can be defined as a change in mass, density, direction, speed, momentum or position, all of which affect either the magnitude and/or direction of the gravitational interaction between the object of the event and all other objects in the universe.

If A and B are events anywhere in the universe then if the events are non-simultaneous b will emit two photons γ_A and γ_B and the order in which they

are emitted correspond to order in which the events took place (figure on the left). But if the events are simultaneous, the changes in gravitational interactions will be additive and b will emit



a single photon γ_{A+B} such that $\vec{P}_{\gamma_{A+B}} = \Delta\vec{G}_A + \Delta\vec{G}_B$ (figure on the right).

Note: since a single photon is emitted, it will be necessary to distinguish the emission of a photon resulting from simultaneous events from the emission of a photon resulting from a single event.

It follows that two events are simultaneous if the variations in the gravitational interactions resulting from the events are additive. And since, as a consequence of gravity being instantaneous, any event must be simultaneously detected by all observers in the universe regardless of their chosen frame of reference and distance. If gravity is instantaneous, then simultaneity must be frame independent and absolute.

Furthermore, position, speed and momentum which can be derived from γ_{D_1} and γ_{D_2} will also be frame independent, determined with certainty and instantaneously.

Can Quantum-Mechanical Description of Physical Reality Be Considered Complete?

If a refutation of Bell's refutation of the EPR paper of the same title were possible, chances are it would have been found a long time ago. Generations of some of the best minds of mathematics and physics have put it to the test.

That said, if we remain rigorous, we must remember that a refutation of the arguments presented in the EPR is exactly what Bell's paper offers and nothing more. The proof of Bell's theorem confirms without doubt that aspects of nature are fundamentally non-local as opposed local when we take the EPR definition of locality. But locality in the EPR paper is kept in agreement with special relativity's prediction that no classical interactions can propagate faster than the speed of light.

It follows that Bell's paper may also be taken as a refutation of locality as derived from special relativity or even as a refutation of special relativity's prediction precluding faster than light interactions.

As we have seen, QGD distinguishes between propagation which is the motion of particles or structures which velocity cannot exceed the speed of light, gravitational interactions which is instantaneous and without mediating particles¹³ and non-gravitation interactions which implies absorption and/or emission of particles and transfer of their momentum. It follows that only non-gravitational interactions are limited to the speed of light.

Implications for Bell Type Experiments

If classical forces and quantum entanglement both violate locality as it is described in the EPR paper and which description assumes that no classical force can propagate faster than c , then how can we know whether a violation of Bell's inequalities is due to a classical or to a quantum mechanical effect? Would this render the proof of Bell's theorem via the violation of Bell's inequality irrelevant? Or should it be taken as taken not as a refutation of the EPR locality, but of the understanding and description of locality it assumes?

If any observed violation of Bell's inequality could be attributed to instantaneous classical effects Bell-type experiments would no longer allows us to distinguish between the two.

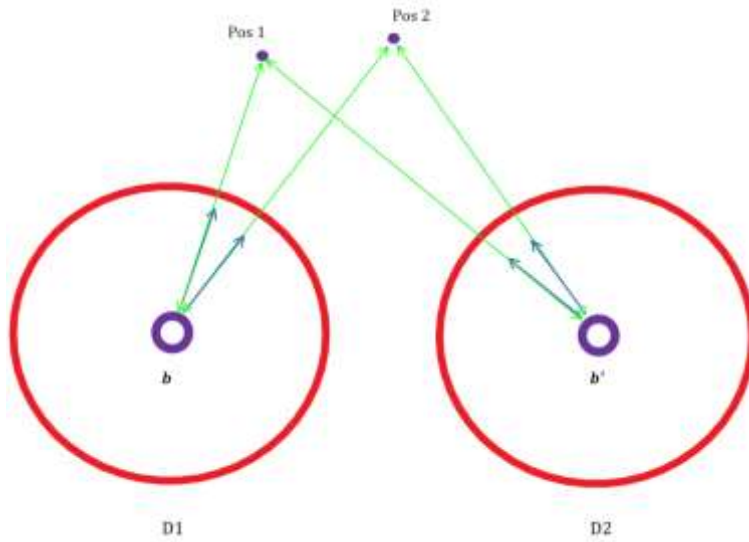
It would however be possible to determine if such violation is caused by classical instantaneous interactions since realism would be preserved and, as we have shown above, we could

¹³ According to QGD, particles do not mediate forces. They can, as in magnetic fields, impart momentum to particles or structures.

simultaneously and with certainty measure conjugate properties such as momentum and position; something that would not be possible if reality was quantum mechanical.

On the Effect of Gravitational Interactions on Particle Decay and how it Can be Used for Gravitational Telescopes

In figure 1, if b and b' are massive nuclei such that $\Delta G(a;b) < m_b$ and $\Delta G(a;b') < m_{b'}$, then b and b' will emit particles x and x' for which $\|\vec{P}_x\| = \Delta G(a;b)$ and $\|\vec{P}_{x'}\| = \Delta G(a;b')$ respectively. So if x and x' are simultaneously emitted (and detected by the array) and their directions converge, then there is a probability that their emissions result from the a change their gravitational interactions between b and b' and a . But when considering that all matter in the universe interacts, the convergence of the directions of the particles emitted by b and b' only means that the objects they interact with are somewhere along the directions



of their emitted particles and that the changes in gravitational interactions are simultaneous. For a gravitational telescope that exploits the effect we described requires that this probability be significantly increased.

This could be done by augmenting the number of massive nuclei of the apparatus. If n is the number of massive nuclei so that

$\Delta G(a;b_i) < m_{b_i}$ where $i \leq n$, then we can predict n simultaneously emitted particles x_i which have the predicted momentum and which directions converge onto a sufficiently small region of space, then for a certain value of n the probability that the simultaneous emission of particles result from the nuclei's gravitational interactions with a approaches certainty. That is, the number of possible objects which would cause the observation is reduced to 1.

A gravitational telescope exploiting the effect can thus discriminate precisely between the objects it observes and provide their position, momentum and mass with certainty.

Note: The type of particles emitted by nuclei will depend on the strength of the bonds between the particles when they were components of the nuclei, their masses as well as the magnitude of the variation in the gravitational interactions. Since, as shown earlier, even small changes in position can cause disproportionately large changes in the physical distance between objects, they induce emissions of particles with significantly greater momentum than would be possible if space were continuous.

Note: The effect described in this section may already have been observed. See [Evidence for Correlations Between Nuclear Decay Rates and Earth-Sun Distance](#) by Jere H. Jenkins, Ephraim Fischbach, John B. Buncher, John T. Gruenwald, Dennis E. Krause, Joshua J. Mattes.

States of Atomic Electrons

In this section, we show how the energy states of atomic electrons follow naturally from the [laws of momentum](#).

For simplicity, we will describe of the energy states of the electron of hydrogen atom system but the same principles apply to complex atomic systems.

A ground state of an atomic electron is the state of equilibrium between the extrinsic forces acting on it. For hydrogen, which consists only of a proton and an electron, the extrinsic forces are the forces between them that act on the electron. For more complex elements, the extrinsic forces are produced by the interactions of a given electron, the other electrons and the components of the nucleus. And as we will see, each of the electrons has a ground state that is dependent on the ground states of all the other electrons.

At ground state $\sum_{i=1}^{n_e} \vec{F}_i = \vec{0}$ where the i indexes the n_a extrinsic forces acting on e^- . These forces are either gravitational (which QGD's equation for gravitational interactions predicts must be over a hundred orders of magnitude greater at the atomic scale than at cosmic scale) or electromagnetic which is actually the resulting effect of the interactions between charges particles and the free *preons*⁽⁺⁾ which as we have seen earlier for the magnetic field.

The third law of momentum dictates that permitted changes in momentum of any particle or structure a is proportional to its mass. That is: $\|\Delta \vec{P}_a\| = \alpha m_a$ or for an electron $\|\Delta \vec{P}_{e^-}\| = \alpha m_{e^-}$ where $\alpha \in N^+$.

Let δ_0 denote the ground state of the electron of a hydrogen atom and γ_0 be a photon such that $\|\vec{P}_{\gamma_0}\| = m_{e_{\delta_0}^-}$. The electron $e_{\delta_0}^-$ can absorb γ_0 since it imparts a change in momentum that respects the third law; that is: $\|\vec{P}_{\gamma_0}\| = \|\Delta \vec{P}_{e^-}\| = \alpha m_{e^-}$ where $\alpha = 1$. After absorption of the photon, the electron's momentum has changed from state δ_0 to state δ_1 . The momentum vector, mass and energy of the electron in δ_1 states are respectively $\vec{P}_{e_{\delta_1}^-} = \vec{P}_{e_{\delta_0}^-} + \vec{P}_{\gamma_0}$,

$$m_{e_{\delta_1}^-} = m_{e_{\delta_0}^-} + m_{\gamma_0} \text{ and } E_{e_{\delta_1}^-} = E_{e_{\delta_0}^-} + E_{\gamma_0} = (m_{e_{\delta_0}^-} + m_{\gamma_0})c.$$

The change in the momentum vector also changes the distance between the electron and the proton so that $\sum_{i=1}^{n_{e_{\delta_1}^-}} \vec{F}_i = \vec{F}_{\delta_1} = -\vec{\Delta P}_{\delta_0 \rightarrow \delta_1}$. So if there is no other force acting on $e_{\delta_1}^-$, it will be pushed back to its δ_0 state and it can be on this state of equilibrium by respecting by emitting a photon

which momentum is equal to the difference in momentum between the two states. That is $\vec{P}_{\gamma'emit} = \vec{P}_{e_{\delta_{\alpha+\alpha'}}^-} - \vec{P}_{e_{\delta_0}^-}$ or, since momentum and energy are numerically equal for photons, we can also say that photon emitted has an energy equal to the difference in the energy between the two states or $E_{\gamma'emit} = E_{e_{\delta_{\alpha+\alpha'}}^-} - E_{e_{\delta_0}^-}$ but the momentum description preferred since it is complete and specific while the energy description is general.

From the above we can generalize in the following manner.

A state δ_α is that which results from a transition $\delta_0 \rightarrow \delta_\alpha$ by photon such that $\|\vec{P}_{\gamma_0}\| = \alpha m_{e^-}$ or by a series of x transitions such that $\sum_{i=1}^x \|\vec{P}_{\gamma_i}\| = \alpha m_{e^-}$.

From this we understand that the difference in momentum of an electron between any two states δ_x and δ_y is $\vec{P}_{e_{\delta_y}^-} - \vec{P}_{e_{\delta_x}^-} = (y - x)m_{e^-}$.

Also, if an electron (or other similarly charged particle) is captured by a proton (or more generally by an atom), it will emit a photon or series of photons which sum will be equal to the difference between its momentum and the momentum of an electron at ground state following the mechanism we described.

The Zeeman Effect

The Zeeman Effect is easily derived from the laws of optics we have described earlier.

A photon can be absorbed $\vec{P}_\gamma = \Delta\vec{P}_{e^-} = \alpha m_{e^-}$. This relation allows us to predict the different states of atomic electrons and assumes that the net magnetic field momentum acting on an electron is zero.

But when a magnetic field is applied, the absorption bands of the electron are split into several bands.

What causes the effect is not a change of the absorption spectrum of the electron itself. The permitted changes in momentum of the electron remain exactly the same. What happens is that that the momentum of the polarized *preons*⁽⁺⁾ from the magnetic field (depending on their direction relative to the magnetic field) added or subtracted to the momentum of photons give a total momentum such $\vec{P}_{H^+} + \vec{P}_\gamma = \alpha m_{e^-}$ and $\vec{P}_\gamma + \vec{P}_{H^-} = \alpha m_{e^-}$. The contribution of the magnetic field makes it possible for some photons which energies lie below and absorption band to be absorbed when $E_H \pm P_\gamma = \alpha m_{e^-}$. The larger E_H is, the more distant the split bands are from the “natural” absorption band.

For $E_H \pm P_\gamma = m_{e^-}$, instead of the absorption band for γ , there will be two absorption bands corresponding to photons γ' and γ'' with momentum $\vec{P}_{\gamma'} = \vec{P}_\gamma - \vec{P}_H$ and $\vec{P}_{\gamma''} = \vec{P}_\gamma + \vec{P}_H$. For $E_H \pm P_\gamma = 2m_{e^-}$ There will be four absorption bands $E_H \pm P_\gamma = 2m_{e^-}$ corresponding to $\vec{P}_{\gamma'_1} = \vec{P}_\gamma - \vec{P}_{H_1} = m_{e^-}$, $\vec{P}_{\gamma'_2} = \vec{P}_\gamma - \vec{P}_H = 2m_{e^-}$, $\vec{P}_{\gamma''_2} = \vec{P}_\gamma + \vec{P}_{H_1} = m_{e^-}$, $\vec{P}_{\gamma''_1} = \vec{P}_\gamma + \vec{P}_H = 2m_{e^-}$.

In special cases when $E_{H\gamma} = \alpha m_{e^-}$, the split of bands will be symmetric to the natural absorption band. When $E_{H\gamma} \neq \alpha m_{e^-}$

Number of bands $nbr_bands = 2\alpha$ for $E_{H\gamma} \neq \alpha m_{e^-}$ and $nbr_bands = 2\alpha + 1$ for $E_{H\gamma} = \alpha m_{e^-}$.

$$\frac{E_H \pm P_\gamma}{\alpha} = m_{e^-} \quad \frac{E_H \pm P_\gamma}{\alpha} = m_{e^-}$$

The momentum of $\vec{P}_{e_{i+1}^-} = \vec{P}_{e_i^-} + \alpha m_{e_i^-} = \vec{P}_{e_i^-} + \vec{P}_\gamma$ and $m_{e_{i+1}^-} = m_{e_i^-} + m_\gamma$ so that the for a photon γ_{i+1} to be absorbed by an electron in the $i + 1$ state, $\vec{P}_{\gamma_{i+1}} = \alpha (m_{e_i^-} + m_{\gamma_i})$.

States of Muonic Hydrogen

In the previous section we have shown that the difference between to states is dependent upon the mass of the electron. This implies that in muonic hydrogen, in which the electron has been replaced by a muon, which particle as greater mass, then the momentum difference between two states of the muon will be greater than the difference between two equivalent states of the electron of ordinary hydrogen.

So to return to ground state from a higher state, since $\|\Delta\vec{P}_\mu\| = ym_\mu$ and $\|\Delta\vec{P}_{e^-}\| = ym_{e^-}$ during the $\delta_y \rightarrow \delta_0$ transition the muon of muonic hydrogen will emit a photon with higher momentum (and energy) than that of photon emitted by the electron of ordinary hydrogen. This is consistent with the measurements of recent experiments¹⁴ which quantum mechanical interpretation led to the proton size problem.

Determination of the Proton Size

Quantum mechanics correctly predicts that the transition energy of an electron between states is the difference between the energies specific to each state. The momentum of the photon emitted

¹⁴ Muonic hydrogen and the proton radius puzzle, R. Pohl, R. Gilman, G. A. Miller, K. Pachucki
<http://arxiv.org/abs/1301.0905>

during the transition between two given states should not be the same for the muonic hydrogen and ordinary hydrogen as shown by recent experiments show that this is not the case.

We have shown that the momentum gaps between two permitted states, known as Lamb shifts, is dependent on the mass of the particle. Therefore, when taking this into account, there will be no discrepancy between the size of the proton derived from hydrogen experiments from that derived from muonic hydrogen or any other experiment.

Radius of a Proton

If the masses of the proton and electron in fundamental units are known, then:

1. Resolve the equation for the electromagnetic effect to obtain the distance between the region occupied by the electron and that which is occupied by the proton and
2. resolve the gravitational interaction equation to find the distance between the electron and the centre of gravity of the proton.
3. The difference between the two will give the radius of the proton.

The QGD description of the electromagnetic effect will be derived and discussed in a dedicated section.

The Photoelectric Effect

Consider a state δ_x of an atomic electron interacting with a photon γ where $\vec{P}_\gamma = m_{e_{\delta_x}}^-$. If

$\vec{P}_{e_{\delta_{x+1}}}^{\vec{A}} > \sum_{i=1}^{n_{e^-}} \vec{F}_i$, then the electron will become unbounded and the momentum of the unbound

electron will be $\vec{P}_{e_{\delta_{x+1}}}^- = \vec{P}_{e_{\delta_x}}^- + \vec{P}_\gamma$. The above $\delta_x \rightarrow \delta_{x+1}$ transition is the photoelectric effect.

Conclusion

We have shown that the mechanisms of atomic electron transition as derived from QGD's axiom set not only describes observations but provides a fundamentally based explanation. Also, the model is consistent with muon states transitions of muonic hydrogen.

QGD Equations Applicability

First, since all fundamental properties are associated with $preons^{(+)}$ and $preons^{(-)}$, and because the properties of neither can be directly measured, it is impossible to experimentally determine their values, therefore we cannot convert QGD units into conventional measurable units. However, assuming that the relations between physical quantities described by QGD are valid, we may use the absolute values of physical properties of mass, momentum, velocity expressed in conventional units and the constants c and k ¹⁵.

Assigning Value to k

QGD's equation for gravitational interactions is $G(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right)$ where m_a and m_b are the absolute masses of objects of a and b . From the question we can predict that

$G(a;b) = 0$ when $k = \frac{d_\Lambda^2 + d_\Lambda}{2}$ (d_Λ is the threshold distance beyond which gravity becomes negative¹⁶). Recent observations¹⁷ suggest that $d_\Lambda \approx 10Mpc$ in which case $k \approx 4.5 \cdot 10^{34}$ when using the meter as unit of distance in the gravity equation.

Assigning Value to c

As we have discussed [earlier](#), for calculations we must substitute the intrinsic velocity of light by it's the absolute velocity of light as given by two-way measurement experiments.

Measurement of Absolute Masses

We can use the equivalence principle as derived by QGD and the equation relating gravitational deflection of light to the mass of the deflecting object to determine the absolute mass of an object.

Let us take the sun for example.

The absolute mass is obtained as follow.

1. Measure the angle of deflection of light from the sun.
2. Use the equation describing the relation between mass of the light deflecting object and resolve it for the mass of the sun m_\odot .

¹⁵ We must however keep in mind that properties such as mass, energy, momentum, velocity, charge, etc., take on different meanings in QGD since it considers intrinsic and absolute.

¹⁶ for $d > d_\Lambda$ gravity becomes negative and is, as we explained, is responsible for the effect we call dark energy

¹⁷ [Dark energy and key physical parameters of clusters of galaxies](http://arxiv.org/abs/1206.1433) <http://arxiv.org/abs/1206.1433>

Measurement of Absolute Velocity

All direct measurements of velocity are relative to a chosen frame of reference. However, it is possible to measure the absolute velocity of the Earth using the redshift effect and once this is known, it becomes possible to deduce the absolute or intrinsic velocities of any object. Continuing with our previous example.

3. Once we know the absolute mass of the sun, we can use QGD's equation for gravity and the absolute motion of the Sun and Earth to calculate the absolute mass of the Earth.
4. The absolute velocity of the Earth can be obtained using the redshift effect described here. Once the absolute velocity of the Earth is known, we can deduce the absolute velocities of other objects from their velocity relative to the Earth.

Rest Mass and Relativistic Mass

Unless an object absorbs particle (which it does only when non-gravitational forces are applied to a body) the mass of an object does not change with speed.

The mass remains equal to the number of *preons*⁽⁺⁾ it contains. What changes under the influence of gravity is the net orientation of their components *preons*⁽⁺⁾, what we call its

momentum given by the equation $\|\vec{P}_a\| = \left\| \sum_{i=1}^{m_a} \vec{c}_i \right\|$. The magnitude of \vec{P}_a increases in towards *b*

when $G(a;b) > 0$ and increases away from *b* when $G(a;b) < 0$ but as we explained it mass

m_a or its energy $\sum_{i=1}^{m_a} \|\vec{c}_i\|$ remain constant.

A body is at rest if its momentum is equal to zero. That is $\sum_{i=1}^{m_a} \vec{c}_i = \vec{0}$.

The relation between mass and energy expressed by $E_a = \sum_{i=1}^{m_a} \|\vec{c}_i\| = m_a c$ where, if we may

remind the reader, the “=” sign symbolizes a proportionality relation and not an equivalence as interpreted by special relativity. Here again, the relativistic and QGD mass are one and the same.

Assigning Value to C

Since $\frac{G(\gamma;a)}{\|\vec{P}_\gamma\|} = \sin(\theta)$ so that $\frac{m_\gamma m_a \left(k - \frac{d^2 + d}{2} \right)}{m_\gamma c} = \sin(\theta)$ then

$$\frac{m_a \left(k - \frac{d^2 + d}{2} \right)}{\sin(\theta)} = c .$$

Note: an alternative approach based on the mechanism QGD proposes for the formation of particles from preons⁽⁺⁾ suggests that $c \approx k$.

Once d_Λ is known, using QGD's equation for gravity, we can also derive the mass of the Sun in preons⁽⁺⁾ and by inserting this value and the angle of deflection of starlight by the sun into the equation describing the gravitational interaction the Sun and light, we can derive the value of c .

Of course, all three methods described above must arrive at the same value of c . That could be a test of the correctness of d_Λ or, depending on the point of view, be taken as a set of equations which unique solution is the actual value of c .

Correspondence between Intrinsic Speed and Conventional Speed

If $v'_a = \frac{d_a}{t}$ and $v'_\gamma = \frac{d_\gamma}{t}$ all that we need to know is that $\frac{v'_a}{v'_\gamma} c = \frac{d_a / t}{d_\gamma / t} c = \frac{d_a}{d_\gamma} = v_a$ so that having a value for c we can go back and forth between the relative speed v'_a and the absolute speed v_a .

Below is a suggested application of QGD to a dynamic system consisting of n gravitationally interacting bodies.

Application to States of Gravitationally Interacting Bodies

The two bodies systems described by the simplified gravitational interaction equation is the basis of the state matrix used to describe the behaviour of a system composed of n gravitationally interacting bodies.

The change in momentum due to gravitational interaction is given by

$$\Delta \vec{P}_a = \Delta G_{1 \rightarrow 2}(a; b) = \frac{\left\| \vec{G}_2(a; b) \right\| - \left\| \vec{G}_1(a; b) \right\| \cos(\theta)}{\left\| \vec{G}_2(a; b) \right\|} \vec{G}_2(a; b) \quad (1)$$

where θ is the angle between $\vec{G}_1(a; b)$ and $\vec{G}_2(a; b)$ which are respectively the gravitational vectors between a and b in states 1 and 2 and $\Delta G_{1 \rightarrow 2}(a; b)$ is understood to be the difference in the magnitude of the gravitational interaction between a and b from state 1 to state 2 (or $1 \rightarrow 2$)

For a system consisting of n gravitationally interacting bodies,

$$\Delta \vec{P}_{a_{i,s+1}} = \Delta \vec{G}(a_i; a_{j,s+1}) = \sum_{j=1}^n \frac{\|\vec{G}_{s+1}(a_i; a_{j,s+1})\| - \|\vec{G}_s(a_i; a_{j,s+1})\| \cos(\theta)}{\|\vec{G}_{s+1}(a_i; a_{j,s+1})\|} \vec{G}_{s+1}(a_i; a_{j,s+1}) \quad (2)$$

where a_i and a_j are gravitationally interacting astrophysical bodies of the system, $j \neq i$ and s and $s+1$ are successive states of the system (a state being understood as the momentum vectors of the bodies of a system at given co-existing positions of the bodies) and $a_{i|s+x}$ is the body a_i and its position when at the state $s+x$. The position itself is denoted $\mathcal{E}_{a_i|s+x}$.

In order to plot the evolution in space of such a system, we must choose one of the bodies as a reference so that the motions of the others will be calculated relative to it. A reference distance travelled by our reference body is chosen, d_{ref} , which can be as small as the fundamental unit of distance (the leap between two *preons*⁽⁻⁾ or *preonic leap*) but minimally small enough as to accurately follow the changes in the momentum vectors resulting from changes in position and gravitational interactions between the bodies.

So given an initial state s , the state $s+1$ corresponds to the state described by the positions and momentum vectors of the bodies of the system after the reference body travels a distance of d_{ref} . For simplicity, we will assign a_1 to the reference body.

$$s+1 = \left\{ \begin{array}{l|l} \vec{P}_{a_{1|s+1}} = \vec{P}_{a_{1s}} + \Delta \vec{G}(a_1; a_{j|s+1}) & \mathcal{E}_{a_1|s+1} \\ \dots & \dots \\ \vec{P}_{a_{n|s+1}} = \vec{P}_{a_{ns}} + \Delta \vec{G}(a_n; a_{j|s+1}) & \mathcal{E}_{a_n|s+1} \end{array} \right\}$$

Using the above state matrix, the evolution of a system from one state to the next is obtained by simultaneously calculating the change in the momentum vectors from the variation in the gravitational interaction between bodies resulting from their change in position. Changes in the momentum vectors have are as explained earlier. Changes in position are given by

$$\mathcal{E}_{a_i|s+1} = \mathcal{E}_{a_i|s} + \frac{v_{a_i}}{v_{a_1}} \frac{d_{ref}}{\|\vec{P}_{a_i}\|} \vec{P}_{a_i}. \text{ The distance travelled by } a_i \text{ from } s \text{ to } s+1 \text{ is } \frac{v_{a_i}}{v_{a_1}} d_{ref} \text{ (for } j=1 \text{ ,}$$

the distance becomes simply d_{ref}) and distance between two bodies of the system at state

$$s+x \text{ is } d_{a_i; a_j|s+x} = \mathcal{E}_{a_i|s+x} - \mathcal{E}_{a_j|s+x}.$$

Of course, we find that for $i = j$, then $d_{a_i; a_j|s+x} = 0$, so that

$$\begin{aligned}\|\Delta \vec{G}_{s+1}(a_{i|s+1}; a_{j|s+1})\| &= \|\vec{G}(a_{i|s+1}; a_{i|s+1})\| - \|\vec{G}(a_{i|s}; a_{i|s})\| \\ &= m_a m_a \left(k - \frac{d_{a_i; a_i|s+1}^2 - d_{a_i; a_i|s+1}}{2} \right) - m_a m_a \left(k - \frac{d_{a_i; a_i|s}^2 - d_{a_i; a_i|s}}{2} \right), \\ &= m_a m_a k - m_a m_a k \\ &= 0\end{aligned}$$

the variation in the gravitational interaction between a body with itself is equal to zero, which implies that its momentum vector will remain unchanged unless $n > 1$ and $\Delta \vec{G}_{j=1}^n(a_{i|s}; a_{j|s+1}) \neq 0$. This is the QGD explanation of the first law of motion.

Note also that for an object a_j freefalling towards an object a_i , $\theta = 0$ so equation (2) becomes

$$\Delta \vec{P}_{a_{i+s+1}} = \Delta \vec{G}_{j=1}^n(a_{i_s}; a_{j_{s+1}}) = \frac{\|\vec{G}_{s+1}(a_{i_s}; a_{j_{s+1}})\| - \|\vec{G}_s(a_{i_s}; a_{j_{s+1}})\|}{\|\vec{G}_{s+1}(a_{i_s}; a_{j_{s+1}})\|} \vec{G}_{s+1}(a_{i_s}; a_{j_{s+1}}) \text{ and}$$

$$\left\| \Delta \vec{G}_{j=1}^n(a_{i_s}; a_{j_{s+1}}) \right\| = \left\| \frac{\|\vec{G}_{s+1}(a_{i_{s+1}}; a_{j_{s+1}})\| - \|\vec{G}_s(a_{i_s}; a_{j_{s+1}})\|}{\|\vec{G}_{s+1}(a_{i_{s+1}}; a_{j_{s+1}})\|} \vec{G}_{s+1}(a_{i_{s+1}}; a_{j_{s+1}}) \right\| = \|\vec{G}_{s+1}(a_{i_{s+1}}; a_{j_{s+1}})\| - \|\vec{G}_s(a_{i_s}; a_{j_{s+1}})\|$$

Alternative Measurements of Earth's Intrinsic Speed

We have seen how the intrinsic speed of the Earth can be measured from type 1a supernovas. Below is an alternative experiment.

If QGD is correct, then it is possible to measure the intrinsic speed¹⁸ of the Earth and other cosmic objects.

All that is needed to do is to measure the one-way distance travelled by light in three mutually perpendicular directions.

Each distance would be measured by a clock each cycle of it being made to correspond to a reference distance which is the distance that light. Since the distance travelled by the Earth is cancelled out in all two way distance measurements of light, then $d_{ref} = \frac{d_c}{n}$ where d_c is the two way distance and n the number of clocks cycles counted between emission and return of the light signal.

¹⁸ Intrinsic speed may be thought as absolute speed by opposition to relative speed.

So $d_{\varepsilon_1} = n_1 d_{ref}$, $d_{\varepsilon_2} = n_2 d_{ref}$ and $d_{\varepsilon_3} = n_3 d_{ref}$ then

$$v_{\varepsilon_1} = \frac{d_c - d_{\varepsilon_1}}{d_c} c , v_{\varepsilon_2} = \frac{d_c - d_{\varepsilon_2}}{d_c} c , v_{\varepsilon_3} = \frac{d_c - d_{\varepsilon_3}}{d_c} c \text{ and } v_{\varepsilon} = \sqrt{v_{\varepsilon_1}^2 + v_{\varepsilon_2}^2 + v_{\varepsilon_3}^2}$$

Measurements of the Intrinsic Speed of a Distant Light Source

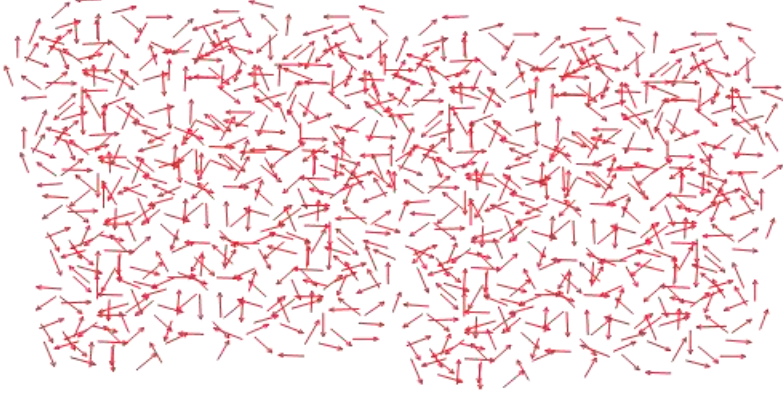
Once the intrinsic speed and direction of the Earth is known, the effect of its effect on the redshift of light received from a distant source can be factored out. Then, using the [QGD's description of the redshift effect](#), we can calculate the intrinsic speed of the distant light source at the time the light was emitted.

However, measurements of variation in gravitational interactions with distant objects would provide their current instantaneous position and speed.

QGD Cosmology

The Initial or Isotropic State

Quantum-geometry dynamics predicts that the universe as we observe it is consistent with an initial state in which only free $preons^{(+)}$ existed and were homogeneously distributed throughout space (we will refer to this state as the initial or isotropic state). The observable



universe is the result of condensation of $preons^{(+)}$ into slow massive particles (dark matter particles), which fused to form visible particles, atoms, gases, the stars, galaxies and galaxy clusters. Therefore, the matter density of the Universe's initial state was homogeneous. That is

$$dens_U = \frac{m_U}{Vol_U}, \text{ where } m_U$$

is the number of $preons^{(+)}$ in the Universe and Vol_U , its volume expressed in $preons^{(-)}$.

We find that the Universe evolved naturally from an initial isotropic state given that the same physical laws that rule the universe today prevailed throughout its entire existence.

Heat, Temperature, Energy of the Initial State

In the initial state of the Universe, QGD theorizes that all $preons^{(+)}$ were free. That means that the energy of the Universe was equal to its heat. So if that its entropy was equal to zero. That is:

$$m_U c - \sum_{i=1}^n P_i = 0, \text{ where } m_U \text{ is the masse of the Universe in } preons^{(+)} \text{ and since all } preons^{(+)}$$

are free $m_U = n$. It follows that the temperature of Universe in its initial state was $T_0^U = \frac{m_U c}{Vol_U}$.

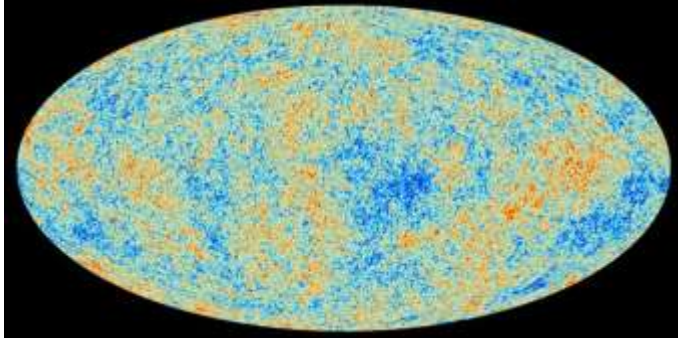
Though the Universe as evolved, its total energy remains $m_U c$, but as particles and structures are formed its heat decreases resulting in an increase in entropy according. In formal terms we have

$$m_U c - \sum_{i=1}^n \|P_i\| > 0).$$

In the upcoming section “Cosmology Derived from Quantum-Geometry Dynamics” we will show that in its initial state the temperature of the universe was $T_0 = \frac{c}{\sqrt{k}}$ where c the kinetic energy of the $preon^{(+)}$ and k the proportionality constant between the n-gravity and p-gravity.

Cosmic Microwave Background Radiation (1st observable state)

We have seen how gravity at the microscopic scale is a hundred orders of magnitudes greater



than that at the Newtonian scale due to the weakness of the n-gravity component of gravity. Gravity at very short distances between $preons^{(+)}$ is such that they become gravitationally bounded and form progressively more massive particles and eventually, neutrinos and photons.

The simplest composite particles are made from two $preons^{(+)}$. In order for two $preons^{(+)}$ a and b to become bounded, they must come at a distance such that $\Delta\vec{G}(a;b) \geq \cos\theta * \vec{P}_{\vec{c}_i}$ where $i \in \{a,b\}$, \vec{c}_i is the momentum of the $preons^{(+)}$ and θ is the angle between converging trajectories.

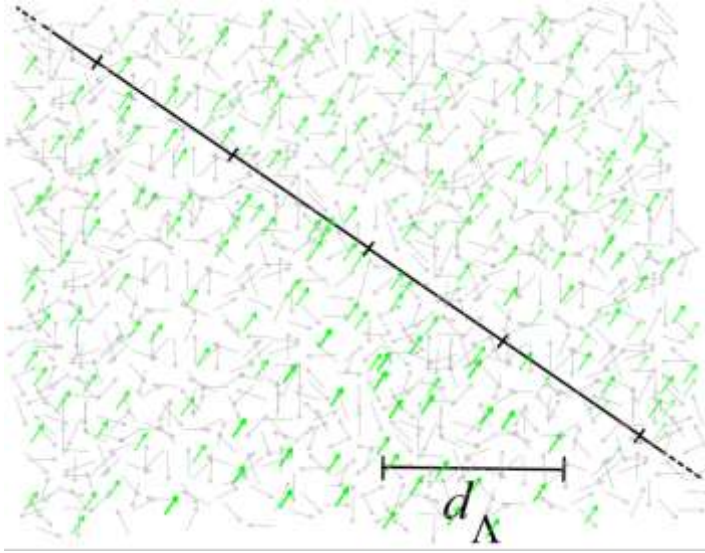
If $\vec{c} \gg \Delta\vec{G}(a;b)$ then, following the initial isotropic state, $preons^{(+)}$ became bound when θ was very small. That is they became bounded when their trajectories are convergent and nearly parallel. **This binding of $preons^{(+)}$ would only happen over large travelling distances exceeding galactic scales and would form photons.**

Photons (or any other particle for that matter) become observable when their momentum is sufficient to affect an electron, that is when $\|\vec{P}_\gamma\| \geq m_e$. A number of particles of the photon and neutrino types formed following the initial preonic state, but the first photons to be observable collectively composed what we know as the cosmic microwave background radiation (CMBR). As we have discussed earlier, the observed isotropy of the cosmic microwave background is a direct and natural consequence of the initial isotropic state.

Note that though the momentum of photons that formed during this stage of the evolution of the Universe possessed the minimum momentum necessary to be absorbed or emitted by electrons, electrons formed at a much later stage of the evolution of the Universe. This suggests that the luminosity of the CMBR was at some point much greater than what is now observed.

Particle Formation and Large Scale Structures

According to QGD, photons gained mass over long distances by binding with other photons and *preons*⁽⁺⁾. During the formation of the CMBR, the particles momentum and energy were equal



and their speed is equal to c or as we have seen

$$\|\vec{P}_\gamma\| = \left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\| = \sum_{i=1}^{m_\gamma} \|\vec{c}_i\| = E_\gamma \text{ and}$$

$$v_\gamma = \frac{\left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\|}{m_\gamma} = \frac{m_\gamma c}{m_\gamma} = c .$$

After travelling over very large distances, some photons became sufficiently massive from the absorption of *preons*⁽⁺⁾ or from merging with other photons for

them to bind with other massive photons when their trajectory intersected at larger angles. That

is when $\Delta \vec{G}(\gamma; \gamma') \geq \frac{\cos \theta^* \vec{P}_\gamma}{\cos \theta^* \vec{P}_{\gamma'}}$. The momentum of the resulting particles would be much

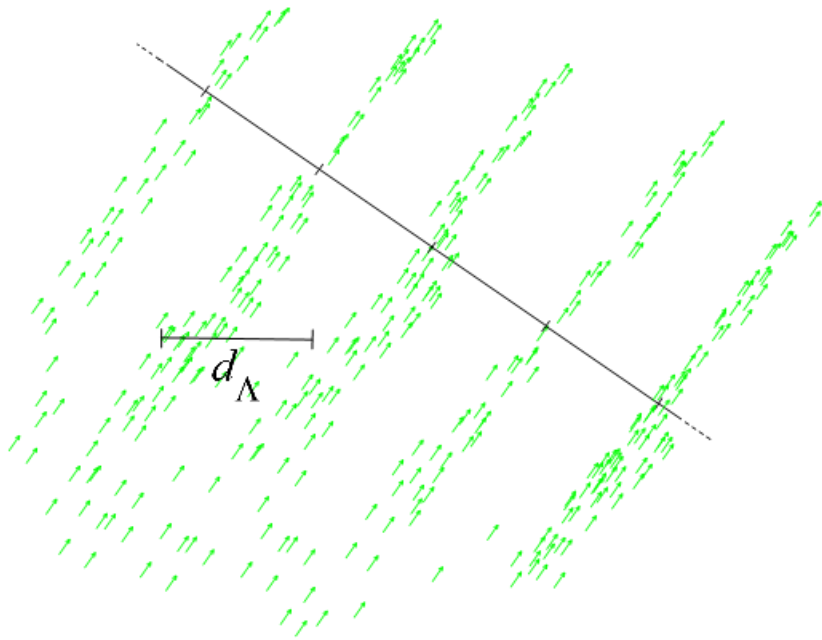
smaller than their combined individual momenta or energies. Hence the velocity of the new particles formed in that way would be orders of magnitude slower than c .

$$\|\vec{P}_{\gamma''}\| = \left\| \sum_{i=1}^{m_\gamma} \vec{c}_i \right\| + \left\| \sum_{i=1}^{m_{\gamma'}} \vec{c}_i \right\| = \left\| \sum_{i=1}^{m_\gamma} \vec{c}_i + \sum_{i=1}^{m_{\gamma'}} \vec{c}_i \right\| < \sum_{i=1}^{m_\gamma} \|\vec{c}_i\| + \sum_{i=1}^{m_{\gamma'}} \|\vec{c}_i\| \text{ and } v_{\gamma''} = \frac{\|\vec{P}_{\gamma''}\|}{m_{\gamma''}} \text{ and since}$$

$$\|\vec{P}_{\gamma''}\| < E_{\gamma''} \text{ then } v_{\gamma''} < c .$$

That is how particles with larger masses and subluminal velocity were produced, some many orders of magnitude slower than c .

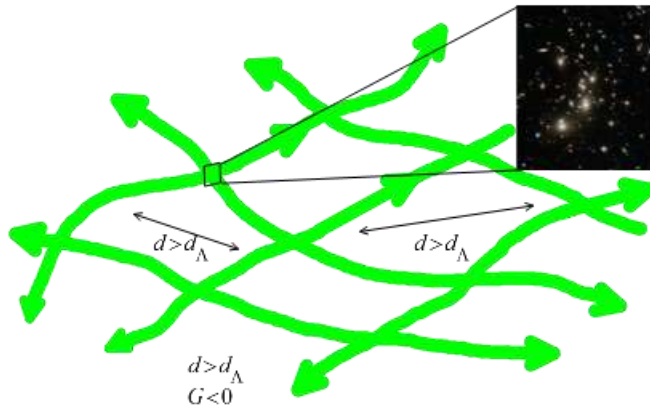
Slow massive particles with momentum less than the minimum allowable change in momentum for an electron are as a consequence not detectable (dark) but they can be indirectly detected through their gravitational interactions with visible matter and light.



Under the effect of gravitational interaction (attractive for $d < d_\Lambda$ and repulsive for $d > d_\Lambda$, where the threshold distance $d_\Lambda \approx 10 \text{ Mpc}$) condensed into streams of dark matter which at their intersection formed halos. It is from and within these halos that progressively more massive particles formed, which eventually created the galaxies and galaxies clusters.

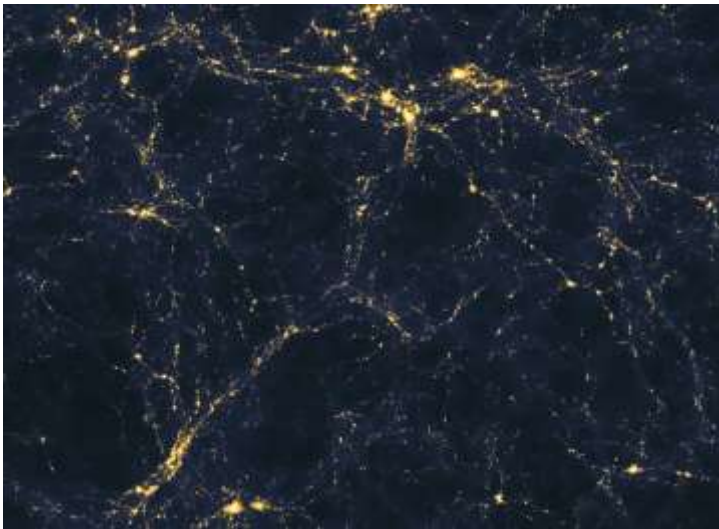
The above figure illustrates streams of dark particles (dark matter), shaped by attractive and repulsive gravity create the filaments of the observed large-scale structure of the Universe. Galaxy clusters are formed at the intersections of two or more streams.

Since the distance between intersections of filaments within which clusters are formed is greater than d_Λ , galaxies belonging to different clusters gravitationally repel each other and causing the expansion of the material Universe. The rate at which galaxies recess from one another is described by the [QGD's equation for gravity](#); hence it increases with distance between them and with their mass and most significantly as a function of their distance from the center of the Universe. Current theories assume that the universe is infinite, but if space is discrete (an axiom of QGD), then the fundamental elements of space, the *preons*⁽⁻⁾, must obey the law of conservation, hence there must be a finite number of them, hence the universe must be spatially finite with a finite number of dimension (three) and a finite amount of matter.



It is important here to emphasize the difference between the expansion of the Universe as it is currently understood, which implies the expansion of space itself, and the material expansion of the large scale structure due to repulsive gravity which requires [space](#) to remain fixed.

Galaxy Formation, Motion, Shape and Evolution



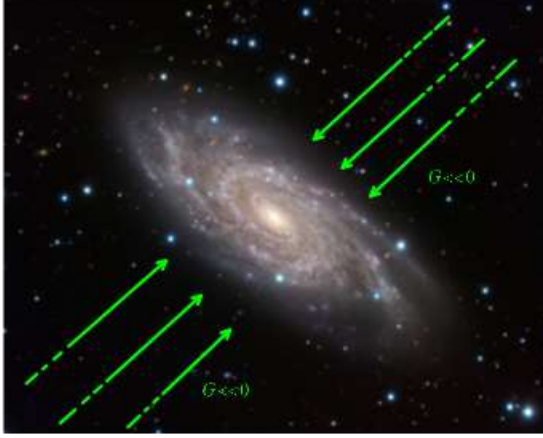
Once particles started to condense to form the large scale structures, the distribution of matter became anisotropic and as a consequence, the non-homogeneous distribution of matter resulted in heterogeneous gravitational interactions between structures.

As more matter condensed, the magnitude of both attractive gravity from within proto-galaxies and net repulsive gravity from matter at distances beyond the

d_Λ threshold increased and became determinant in shaping galaxies.

A galaxy will be shaped by the gravitational interactions with other galaxies within their clusters, but even more so between galaxies belonging to different clusters at very large distances.

For example, when the net gravity acting on a galaxy is along one axis, the galaxy will be flattened. Similarly, when the distribution of structures a galaxy interacts with is irregular, then its shape will be irregular. The more homogeneous the distribution of matter interacting with a galaxy, the more spherical it will be. Therefore from the shape of galaxies, we can deduce the gravitational interactions it is subjected to and from it, the distribution of the structures gravitationally acting on them.



Galaxy Dynamics

In order to correctly describe the dynamics of galaxies we need to take into account all gravitational interactions.

An object b becomes locked into orbiting a more massive object a when the magnitude of the component momentum vector of b in direction of a is cancelled out by gravity. That

is: $\vec{P}_b \cos \theta = - \Delta \vec{G}_{p_1 \rightarrow p_2}(a; b)$ where

$$\Delta \vec{G}_{p_1 \rightarrow p_2}(a; b) = \vec{G}_{p_2}(a; b) - \vec{G}_{p_1}(a; b) \cos \theta \text{ and } \theta \text{ is}$$

the angle between $\vec{G}_{p_1}(a; b)$ and $\vec{G}_{p_2}(a; b)$.

\vec{P}_b is itself resultant the momenta of the components from which it was formed (see [laws of momentum](#)) and the gravitational interactions it is subjected to. For example, a star x belonging to a galaxy a within a given cluster, \vec{P}_x will be the resultant momenta of the converging streams of particles within which its cluster was formed and the gravitational interactions it is subjected to.

In the simplest case, the speed of an object b in orbit at a radial distance r from the center of a massive structure a is $\vec{v}_b = \frac{\vec{P}_b}{m_b} = \frac{\Delta \vec{G}_{p_1 \rightarrow p_2}(a; b)}{m_b \cos \theta}$, but this simplest case is only to serve as a basis describe gravitational interactions which in reality are always much more complex.

For one, we must take into account gravitational effects attributed to dark matter.

Dark Matter Halo Density Distribution

In order to correctly describe the motion of stars within a galaxy, we must first understand the distribution of [dark matter](#) in the region containing the galaxy. Unlike other models which treat dark matter as an exotic type of matter, QGD predicts that all matter is fundamentally composed of $preons^{(+)}$, themselves dark, which become bounded to form progressively more massive particles which as we have explained earlier become visible matter when photons they absorb or emit have at least the minimum momentum necessary to be absorbed by an electron.

This implies that Δm_{vm} , the rate at which visible matter is created from dark matter, must be proportional to the dark halo density Ω_{dm} but also that there is a critical density Ω_{min} below which visible matter cannot form. As a consequence, the density of the dark matter is not expected to increase as we get closer to the center of a galaxy as dominant dark matter models

predict. Under the influence of gravity, dark matter would concentrate towards the center, but the higher rate of production of visible matter would tend towards keeping Ω_{dm} below Ω_{min} .

QGD predicts that $\Omega_{dm} \approx \Omega_{min}$ within a radius $r < d_{\Omega_{min}}$ where $d_{\Omega_{min}}$ is the distance beyond which $\Omega_{dm} < \Omega_{min}$. This dynamics which limits the increase of dark matter density towards the center of a galaxy is consistent with the observed flat dark matter density profiles of galaxies^{19,20}. Thus QGD precludes the formation of the dark matter cusps predicted by dominant dark matter models (see [cuspy halo problem](#)).

Rotation Curve of Galaxies

QGD's equation for gravity and its predicted for dark particles (particles for with $\|\vec{P}\| < m_e$) explain the observed rotation curves of galaxies.

The orbital velocity of a star is $\vec{v}_b = \frac{\vec{P}_b}{m_b} = \frac{\Delta\vec{G}(a;b)}{m_b \cos \theta}$ where

$$\begin{aligned}\Delta\vec{G}(a;b) &= \Delta\vec{G}^+(a;b) + \Delta\vec{G}^-(a;b) \\ &= \Delta m_a * m_b k + \Delta m_a m_b * d\end{aligned}$$

Note that the p-gravity and n-gravity components of QGD's equation for gravity

$\vec{G}(a;b) = m_a m_b \left(k - \frac{d^2 + d}{1} \right)$ must be differentiated separately since gravity is the resultant

effect of the p-gravity force which is a function of mass only while n-gravity force is a function of both mass and distance. When only taking into account two objects with constant masses, then

$\Delta\vec{G}^+(a;b) = 0$ and $\Delta\vec{G}(a;b) = \Delta\vec{G}^-(a;b)$, and objects behave as if governed by Newtonian gravity with gravity diminishing as a function of the square of the distance and

$\Delta\vec{v}_b = \frac{\Delta\vec{G}^-(a;b)}{m_b}$ and $\Delta\vec{v}_a = \frac{\Delta\vec{G}^-(a;b)}{m_a}$. The action is the same but where Newtonian gravity

is strictly attractive with variations due to variations in distance between a and b , QGD attributes the change in gravity variations in repulsive gravity (n-gravity) as a function of distance.

¹⁹ Moore, Ben; et al. (August 1994). "Evidence against dissipation-less dark matter from observations of galaxy haloes". *Nature*. **370** (6491): 629–631. [Bibcode:1994Natur.370..629M](#). [doi:10.1038/370629a0](#).

²⁰ Oh, Se-Heon; et al. (May 2015). "High-resolution Mass Models of Dwarf Galaxies from LITTLE THINGS". *The Astronomical Journal*. **149** (6): 180. [arXiv:1502.01281](#). [Bibcode:2015AJ....149..180O](#). [doi:10.1088/0004-6256/149/6/18](#)

In order to describe the rotation curve of a galaxy, we need to consider the influence of both visible and dark matter. That is, if R_a is a spherical region of space with radius $r = d$ which center coincides with the center of a galaxy a and then the mass of matter within R_a is

$m_{R_a} = m_a + m_{dm}$, where m_a and m_{dm} are respectively the amount of visible matter and dark

matter in R_a , then $\Delta \vec{v}_b = \frac{\Delta \vec{G}^+(m_{R_a}; b) + \Delta \vec{G}^-(m_{R_a}; b)}{m_b}$.

$$\Delta \vec{G}^+(m_{R_a}; b) = \Delta m_{dm} m_b k \text{ and since } \Delta m_{dm} = 4\pi r^2 \Omega_{dm} \text{ ,}$$

$$\begin{aligned} \Delta \vec{G}(R_a; b) &= \Delta \vec{G}^+(R_a; b) + \Delta \vec{G}^-(R_a; b) \\ &= 4\pi r^2 \Omega_{dm} m_b k - 2\pi r^3 \Omega_{dm} m_b \end{aligned}$$

and

$$\begin{aligned} \Delta \vec{v}_b &= 4\pi r^2 \Omega_{dm} k - 2\pi r^3 \Omega_{dm} \\ &= 4\pi r^2 \Omega_{dm} \left(k - \frac{r}{2} \right) \end{aligned}$$

And if the density of dark matter is inversely proportional to the square of the distance from the center of the galaxy then $\Delta \vec{v}_b = 4\pi r^2 \frac{\alpha_{dm}}{r^2} \left(k - \frac{r}{2} \right) = 4\pi \alpha_{dm} \left(k - \frac{r}{2} \right)$, hence the observed flattening of the rotation curve of galaxies.

Recession Speed between Large Structures

The rate at which large structures accelerate away from each other is proportional to the variation in the gravitational repulsion between two positions and is given by

$$\Delta v_a + \Delta v_b = \frac{\Delta G(R_a; R_b)}{m_a} + \frac{\Delta G(R_a; R_b)}{m_b}.$$

If the universe evolved from an isotropic state such as we described earlier, then the speed of a structure b relative to a structure a is equal to the total acceleration between d_Λ , the threshold distance at which gravity becomes repulsive, and d the distance between the

structures a and b . That is,

$$v_{rel} = v_a + v_b = \frac{\sum_{d_\Lambda}^d \Delta G(R_a; R_b)}{m_a} + \frac{\sum_{d_\Lambda}^d \Delta G(R_a; R_b)}{m_b} = \frac{m_a + m_b}{m_a m_b} \sum_{d_\Lambda}^d \Delta G(R_a; R_b).$$

The acceleration from a galaxy from a large structure is independent of its mass but only dependent on the mass of the structure it is receding from.

Like acceleration from attractive gravity, acceleration from repulsive gravity is directly proportional to the distance. The derivative of QGD's equation for gravity over distance gives the gravitational acceleration over a distance or $v_{R_a} = m_{R_b} d$.

Then $v_{rel} = v_{R_a} + v_{R_b} = (m_{R_a} + m_{R_b}) d$ where d may be understood as the proper distance between R_a and R_b .

The acceleration of the rate of recession between a and b is

$$\Delta v_{rel} \simeq (m_{R_a} + m_{R_b}) \frac{d^2 - d_\Lambda^2}{2} = (m_{R_a} + m_{R_b}) d$$

However, the recession speed between two structures does not only depend on the distance and masses of the structures, but on all masses and structures each interact with, that is, it depends on the gravitational interactions with the rest of the universe, therefore, it depends on each galaxies positions relative to the center of the galaxy. This is measured using the cosmological redshift as discussed in the following section.

Expansion Rate of the Material Universe and the Cosmological Redshift

According to QGD, space is composed of a finite number fundamental discrete units, $preons^{(-)}$, which makes space a static structure through in which all matter exists. Hence space is finite and must have a center and an edge.

Material structures are strictly kinetic and as we have seen in previous sections gravitationally attract or repel one another depending on whether the distances that separate them is smaller or greater than the threshold distance d_Λ .

We define the cosmological acceleration as the effect of gravity on structures at a scale at which structures are separated by distances greater than the threshold distance beyond which gravity becomes repulsive or $d > d_\Lambda$. At the cosmological scale, since gravity is repulsive, the structures accelerate away from the center of the Universe at a rate that is proportional to their distance from the center and the inversely proportional to their shortest distances from the edge of the Universe.

For an object a at a distance r from the center of the Universe and d_U , the diameter of the universe, we find that $\Delta \vec{P}_a = \Delta \vec{G}(m_{R_1}; m_a) + \Delta \vec{G}(m_{R_2}; m_a)$ where $m_{R_x} = vol_{R_x} \frac{m_U}{Vol_U}$.

Observationally, objects at the cosmological scale that are closer than we are to the center of the universe will appear blue shifted relative to light from the center of our galaxy and objects that are further than we are from the center of the Universe will appear redshifted relative to it.

However, since the cosmological acceleration affects a galaxy as a whole with negligible differences on individual components of a galaxy, we would observe within a galaxy stars that may be redshifted or blue shifted relative to a reference star depending on whether the observed star is respectively closer or further from the center of the galaxy.

Black Holes and Black Holes Physics

QGD predicts the existence of structures which exert such gravitational pull that photons cannot escape. But contrary to the classical black holes predicted by relativity, the black holes predicted by quantum-geometry dynamics are not singularities. The QGD exclusion principle which states that a $preon^{(-)}$ cannot be occupied by more than one $preon^{(+)}$ implies that quantum-geometrical space imposes a limit to the density any structure can have. The density of black holes is also limited by the fact that $preons^{(+)}$, being strictly kinetic, they must have enough space to keep in motion. It follows that black holes must have very large yet finite densities.

Angle between the Rotation Axis and the Magnetic Axis

The effect of the helical motions of the electrons in direction of the rotation of a body adds up so that, at a large scale, the body behaves as a single large electron which though helical trajectory around the body interacts with the neighbouring preonic region to generate a magnetic field.

Since the magnetic field is the result of the polarization of free $preons^{(+)}$ along the loops of the helical trajectory, and since the inclination of these loops increases with the speed of rotation, so does the angle between these loops and the axis of rotation increases. It follows that the angle between the axis of rotation and the magnetic axis for bodies of given material composition is proportional to the speed of rotation about its axis and its diameter.

This angle between the axis of rotation and the magnetic axis is small for slowly rotating bodies but can never be so small that the axes coincide. From the above, it also follows that a faster rotation not only implies a larger angle between the rotation axis and the magnetic axis is, but also a flattening of the magnetic field and an increase in its intensity.

The Inner Structure of Black Holes

To understand the structure of a black hole we will look at what happens to a photon when it is captured by it the gravitational pull.

The model for light refraction that we introduced in earlier articles can be applied directly to photon moving through a black hole. Since we assume that the black hole is extremely massive, its trajectory will bring it towards the center of the black hole.

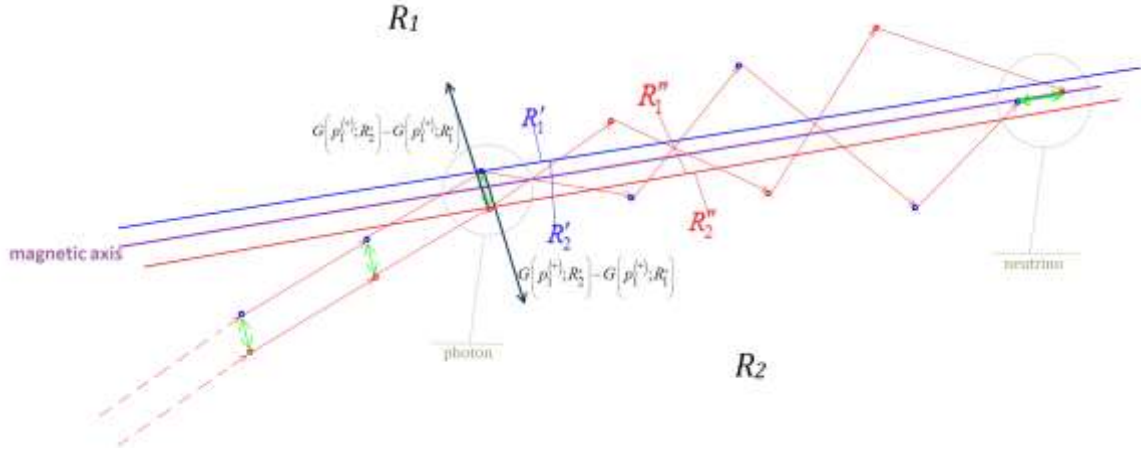
When moving along the magnetic axis of the black hole, the component $preons^{(+)}$ of the $preon^{(+)}$ pairs of the photon are pulled away from each other, splitting the photon into free $preons^{(+)}$ which may or not recombine into neutrinos. This works as follow:

As we have seen earlier in this book, the force binding the $preons^{(+)}$ of a $preon^{(+)}$ pairs is gravitational. The QGD gravitational interaction between particles at the fundamental scale is $G(a;b) = m_a m_b \left(k - \frac{d^2 + d}{2} \right)$, and since a and b are $preons^{(+)}$, $m_a = m_b = 1$ and since $d = 1$, the binding force between two $preons^{(+)}$ of a $preon^{(+)}$ pair is equal to $k - 1$.

For a photon moving along the magnetic axis, we have and $G(p_1^{(+)}; R_2') - G(p_1^{(+)}; R_1') > k - 1$ where $p_1^{(+)}$ and $p_2^{(+)}$ are the component $preons^{(+)}$ of a $preon^{(+)}$ pair of a photon.

The regions R_1 and R_2 , on each side of the black hole axis are equally massive regions. If we call R_1' and R_2' the regions each side of $p_1^{(+)}$ when the photon's trajectory is aligned with the black hole axis then $R_2' > R_1'$ and $G(p_1^{(+)}; R_2') - G(p_1^{(+)}; R_1') > k - 1$. Similarly, if we call R_1'' and R_2'' the region on the each side $p_2^{(+)}$ then $R_1'' > R_2''$ and $G(p_2^{(+)}; R_1'') - G(p_2^{(+)}; R_2'') > k - 1$. So the force pulling the $preons^{(+)}$ of $preon^{(+)}$ pairs being greater than the force that binds them, the $preon^{(+)}$ pairs are split into single $preons^{(+)}$.

How do we that the gravitational forces within a black hole are sufficiently strong to cause the photons to be broken down into $preons^{(+)}$? If the gravitational forces within the black hole were not enough to breakdown the photons, then photons moving along a black hole axis would escape into space making the black hole visible. Since black holes do not emit light, then the gravitational interactions must be strong enough to break photons down into $preons^{(+)}$ and neutrinos.



The image above shows how a simple two $preons^{(+)}$ photon is split into two free $preons^{(+)}$ which because of the electro-gravitational interactions move back toward the magnetic axis. But, because the quantum-geometrical space occupied by the black holes is densely populated by particles which affect randomly the trajectories of the single $preons^{(+)}$, our two $preons^{(+)}$ arrive at the magnetic axis of the black hole at different positions. And if they are in close enough proximity, the single $preons^{(+)}$ will combine to form a neutrino which structure, not being made of $preons^{(+)}$ pairs, remains structurally unaffected by the intense gravitational interactions within the black hole.

Once the trajectories of the $preons^{(+)}$ or the neutrino coincides with the magnetic axis of the black hole, the $preons^{(+)}$ or neutrinos will move through the center of the black hole and will exit it. $Preons^{(+)}$ and neutrinos can escape the gravitation of the black hole because gravitational interactions, though it affects the directions of $preons^{(+)}$, doesn't change their momentums which, as we have seen in earlier articles is fundamental and intrinsic (the momentum of a $preon^{(+)}$ is $\|\vec{c}\|$ where \vec{c} is momentum vector of a $preon^{(+)}$).

It follows, that all matter that falls into a black hole will be similarly disintegrated into $preons^{(+)}$ and neutrinos, which will exit the black hole. The black hole will thus radiate $preons^{(+)}$ and neutrinos, in jets at both poles of their magnetic axis of rotation. Since $preons^{(+)}$ and neutrinos interact too weakly with instruments to be detected by our instruments, they are invisible to them. In order to see the $preons^{(+)}$ -neutrinos jets from a black hole, instruments may need detectors larger than our solar system. However, the jets can be observed indirectly when they interact with large amount of matter when the polarized $preons^{(+)}$ and neutrinos they contain impart it with their intrinsic momentum. It is worth noting that polarized preons and neutrinos jets, as described by QGD, would contribute to the observed dark energy effect.

Based on QGD's model of the black hole, we can predict that the $preons^{(+)}$ /neutrino jets will form an extremely intense polarized $preons^{(+)}$ field along the magnetic axis creating the equivalent of a repulsive electromagnetic effect at both poles. The polarized preonic field would repulse all matter on their path, which may explain the shape of galaxies.

From what we have discussed in the preceding section, we can define a black hole as an object which mass is such that it can breakdown all matter, including photons, into $preons^{(+)}$. Therefore, any emission by a black hole being preonic, they are not visible. However, intense preonic fields (which as we have seen are essentially intense magnetic fields), will impart momentum to particles and structures, bringing them into excited states from which they emit photons.

The QGD model of the physics of black hole has another important implication. The $preons^{(+)}$ and neutrinos resulting from the breakdown of a particle or structure are indistinguishable from the $preons^{(+)}$ or neutrinos resulting from the breakdown of any other particle or structure. This means, if QGD is correct, that all information about the original particle or structure is lost forever. That said, since this consistent from QGD's axioms set and since, unlike quantum mechanics, QGD does not require that information be preserved, the loss of information it predicts does not lead to a [paradox](#) (see [this article](#) for an excellent introduction to subject).

Density and Size of Black Holes

QGD predicts that black holes are extremely dense but not infinitely so. Considering that $preons^{(+)}$ are strictly kinetic and that no two can simultaneously occupy any given $preons^{(-)}$ then $\max density_{BH} = \frac{1preon^{(+)}}{2preons^{(-)}} \text{ or } \frac{1}{2}$. It follows that $\min Vol_{BH} = 2m_{BH}preons^{(-)}$ or, since $preon^{(-)}$ is the fundamental unit of space, we can simply write $\min Vol_{BH} = 2m_{BH}$ for the minimum corresponding radius $\min r_{BH} = \left[\sqrt[3]{\frac{3m_{BH}}{2\pi}} \right]$.

For the radius of the black hole predicted to be at the center of our galaxy, $m_{BH} \approx 4*10^6 M_{\odot}$

and $\min r_{BH} = \left[\sqrt[3]{\frac{3m_{BH}}{2\pi}} \right] \approx 1.24*10^2 M_{\odot}$ where the mass is expressed in $preons^{(+)}$ and radius

in $preons^{(-)}$. Though converting this into conventional units requires observations to determine the values of the QGD constants k and c , using relation between QGD and Newtonian gravity, we also predict that the radius within which light cannot escape a massive structure is $r_{qgd} = \sqrt{G_{const} \frac{M}{c}}$ where G_{const} is used to represent the gravitational constant.

Since the Schwarzschild radius for a black hole of mass M_{BH} is $r_s = G_{const} \frac{M_{BH}}{c^2}$ then

$$r_{qgd} = \sqrt{c r_s} .$$

Using r_{qgd} to calculate $\delta_{r_{qgd}}$ the angular radius of the shadow of Sagittarius A*, the black hole at the center of our galaxy, where $M_{BH} = 4 * 10^6 M_{\odot}$ we get $\delta_{r_{qgd}} \approx 26.64 * 10^{-5}$ arcseconds which is about 10 times the angular radius calculated using the Schwarzschild radius which is

$\delta_{r_s} = 27.6 * 10^{-6}$ arcseconds. This prediction will be tested in the near future by the upcoming observations by the [Event Horizon Telescope](#).

Neutron Stars, Pulsars and Other Supermassive Structures

When the mass of a structure is sufficient to bind photons, but insufficient to breakdown photons, electrons and positron, we get a stellar structure which can emit these particles.

The internal gravitational interactions will redirect particles towards the magnetic axis of the stellar structures where, when its trajectory coincides with an axis, the gravitational force from the stellar object acting on the particles will cancel out and the particle will escape the object into outer space. Such structures may correspond to what we call [neutron stars](#). So what distinguishes neutron stars from black holes is that we have $G(p_1^{(+)}; R_2') - G(p_1^{(+)}; R_1') < k - 1$ and $G(p_2^{(+)}; R_1'') - G(p_2^{(+)}; R_2'') < k - 1$. That is, the gravitational force within the neutron star which acts on particles is insufficient to breakdown photon, electron and positrons.

Another prediction is that distinguishes quantum-geometry dynamics is that neutron stars are not composed of neutrons. The internal gravitational forces being such that they would break down all particles into neutrinos, photons, electrons and positrons.

Pulsars

When a neutron star rotates at a sufficiently high rate, it interacts with the preonic field in such a way that it creates an intense magnetic field. Such magnetic field will be sufficiently strong to curve the trajectory of all neutrinos, photons, electrons and positrons that move past its surface back into pulsar. Particles that move along its axis of rotation, along which the electromagnetic force cancel out, will escape at the magnetic poles producing the known bidirectional emission characteristic of [pulsars](#).

The Preonic Universe

According to the principle of strict causality we can deduce the following:

Preons⁽⁺⁾ and *preons*⁽⁻⁾, are fundamental. As such and in accordance with the [fundamentality theorem](#), they have no components; hence they require no pre-existing

conditions to exist. From this and to be in accordance with the Law of Conservation, all $preons^{(+)}$ and $preons^{(-)}$ always existed.

That is, $preons^{(+)}$ and $preons^{(-)}$ not only existed at the origin of the Universe. They are *the* origin of the Universe.

It follows that in its initial phase, the Universe consisted of $preons^{(+)}$ uniformly distributed throughout the entire quantum-geometric space of the Universe; the preonic universe.

The theory proposes that the n-gravity and p-gravity fields were in perfect equilibrium. That is:

$$k(m_U^2 + m_U) / 2 = (Vol_U^2 + Vol_U) / 2$$

Where m_U is the mass of the preonic universe and Vol_U is the number of $preons^{(-)}$ its space is composed of. But since $\lim_{x \rightarrow \infty} \left(\frac{x}{x^2} \right) = 0$, at the macroscopic scale, the relative value of m_U and Vol_U become negligible and we can simply write²¹:

$$km_U^2 / 2 \approx Vol_U^2 / 2$$

Also, from the QGD definitions of heat, temperature and entropy we know that, since in the primordial universe contained only free $preons^{(+)}$, the heat it contained was equal to its energy, that is $Heat = \sum_{i=1}^{m_U} \|\vec{c}_i\| = m_U c$, its temperature was $\frac{m_U c}{Vol_U}$ and its entropy being the difference between its energy and heat, and heat and energy being equal in the preonic universe, its entropy was equal to zero.

Interestingly, since $Vol_U = \sqrt{km_U^2}$ the temperature of the preonic universe is given by

$$\frac{m_U c}{\sqrt{km_U^2}} = \frac{c}{\sqrt{k}}.$$

Hence, the temperature of the preonic universe is a ratio of c and k ; the two fundamental constants of quantum-geometry dynamics.

²¹Since QGD implies that all quantities are finite, even mathematical quantities, ∞ represents the largest theoretical quantity of any physical property. In this equation it may be taken as the number of n-gravity interactions in the universe.

Future Evolution of the Universe

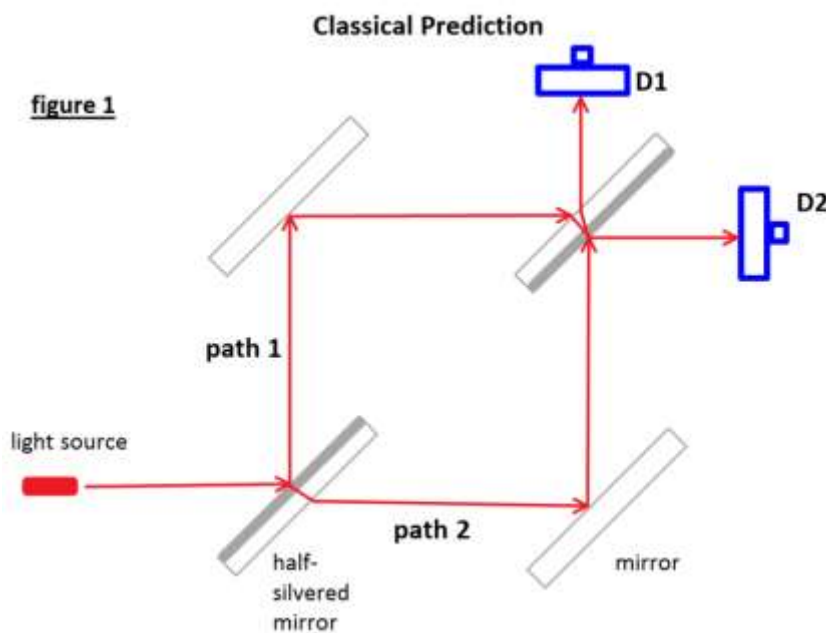
If QGD's description of the universe is correct, then most matter would eventually collapse into black holes where it would be broken down into *preons*⁽⁺⁾ which would be emitted and would reseed the universe, resetting the initial isotropic state.

One question remains. What will happen to the galaxies that will be pushed to the limits of the universe?

QGD Interpretations of Quantum Entanglement Experiments

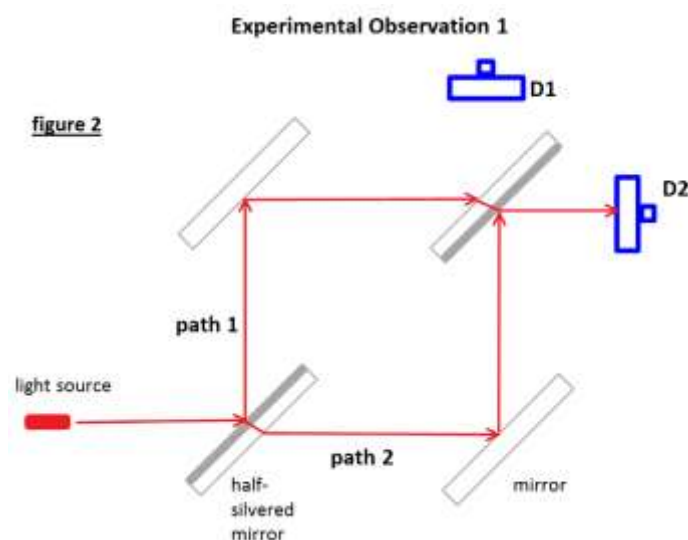
Preonics provides simple and realistic explanations of observations of so-called quantum entanglement experiments. Not only are QGD predictions consistent with such experimental observations but, unlike quantum mechanics, it precisely explains the mechanisms responsible for observed outcomes without violating the [principle of locality](#).

In the setup shown in figure 1, which is called a [Mach-Zehnder Interferometer](#), photons from a light source are first split into two beams by the half-silvered mirror at the bottom left which will follow two distinct paths. Classical optics predicts that the photons on path 2 will be reflected by the mirror on the bottom right to the half-silvered mirror on the top right which will split the beam



into two smaller beams each containing 25% of the photons from the source, directing one towards D1 and the second towards D2.

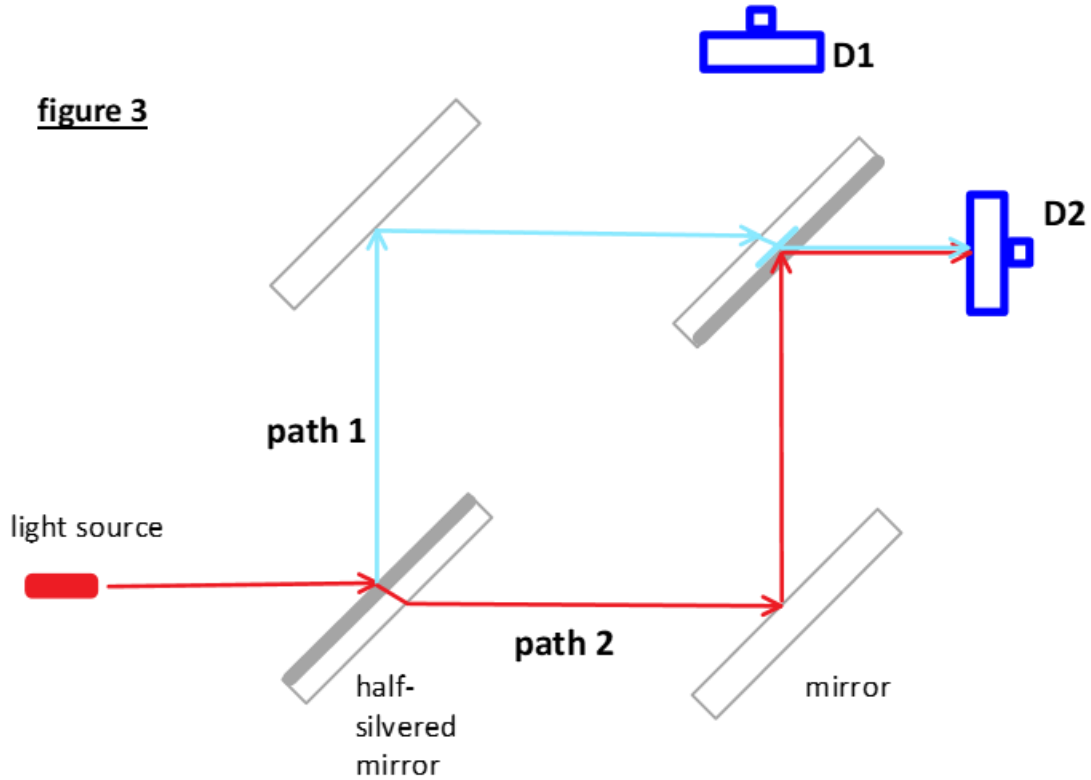
Similarly, the beam on path 1 will be split by the half-silvered mirror at the top right into two beams containing each 25% of the photons, one directed to D1 and the other to D2. So, each of the detectors will receive 25% of the photons that follow path 1 and 25% of the source photons through path 2 for a total of 50% of the photons.



However, observations show the classical prediction to be incorrect and finds that 100% of the photons from the source reach D2 and none reach D1 (figure 2).

Quantum mechanics, in a way that is similar to [double-slit experiments](#), explains that all photons travel through both paths and interfere constructively at D1 and destructively at D2.

As discussed earlier, the momentum of any particle or structure a can only change by discrete amount following the relation $\|\Delta\vec{P}_a\| = xm_a g^-$ where x is an positive integer, m_a is the mass of the particle or structure (the number $preons^{(+)}$ of its composed from) and g^- is the fundamental unit of n-gravity (the repulsive force acting between $preons^{(-)}$, the discrete units of space). For e_0^- , the permitted change in momentum is $\|\Delta\vec{P}_{e_0^-}\| = xm_{e_0^-} g^-$, so only a photon γ with momentum $\|\vec{P}_\gamma\| = \|\Delta\vec{P}_{e_0^-}\|$.



What we observed in our setup is photons from the source that follow path 1 (color coded blue) are transitorily absorbed by the electrons of the glass of the top right mirror. The energy states of the electrons changes from e_0^- to e_1^- (blue rectangle of the top right half-silvered mirror in figure 3). Since $m_{e_1^-} = m_{e_0^-} + m_\gamma$, the permitted change in momentum of e_1^- is $\|\Delta\vec{P}_{e_1^-}\| = x(m_{e_0^-} + m_\gamma) g^-$. Since $\|\vec{P}_\gamma\| < \|\Delta\vec{P}_{e_1^-}\|$, the momenta of the photons along from path 2 are smaller than the permitted change in momentum for e_1^- , they will be reflected towards D2 by the [mechanism of reflection we described earlier](#). The e_1^- electrons form essentially form a reflective surface for all

photons for which $\|\vec{P}_\gamma\| < \|\Delta\vec{P}_{e_1}\|$. Therefore, none of the photons ever reached D1 because 100% of them were directed at D2.

figure 3a

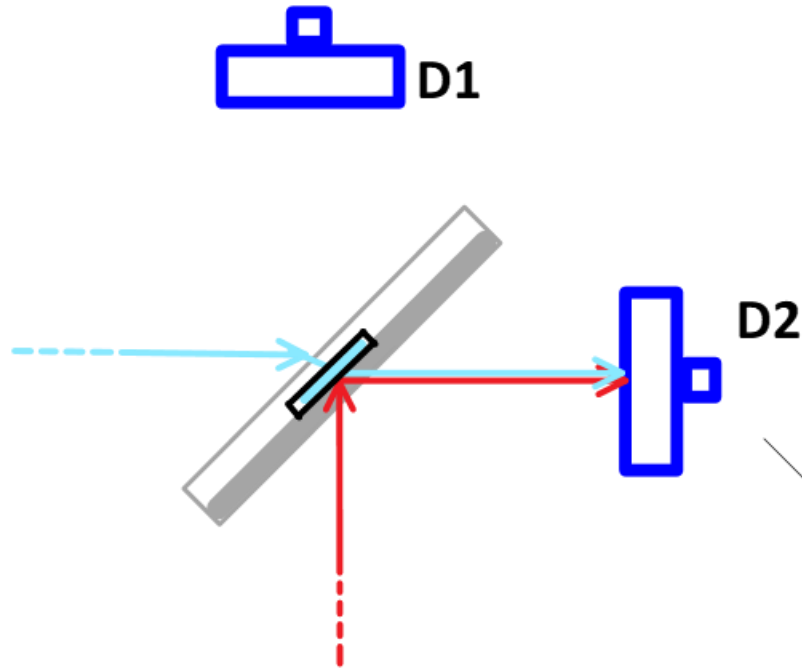
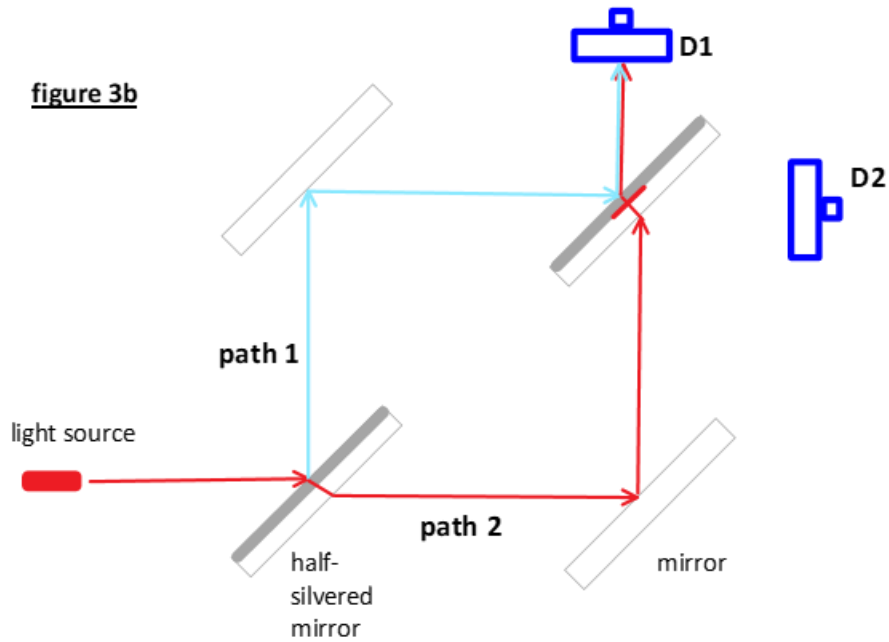
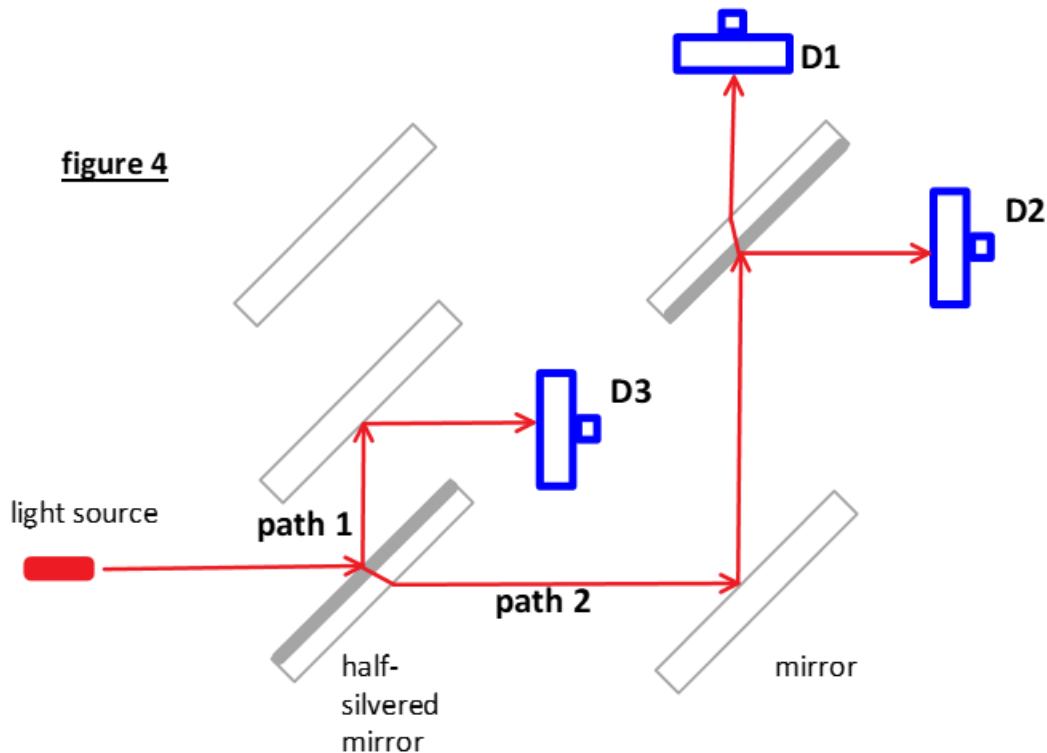


Figure 3b below shows QGD the same experiment with the silvered side of the top right half-silvered mirror facing D1.



Experimental Observation 2



Now consider the setup shown in figure 4. Observations show that in this setup 50% of the photons reach D3, 25% of the photons that will reach each of D1 and D2 detectors.

According to quantum mechanics, the photons moving along path 2 that reach D1 can only do so if the photons moving along path 1 are deflected towards D3. This raises the question: How can the photons that reach D1 know that the photons of path 1 were deflected towards D3?

The quantum mechanical explanation is that the photons from path 1 and path 2 are entangled, so a measurement (detection) of photons by D3 influences photons at D1 and D2, and does so instantly and independently of the distance that separates the detectors. This, of course, violates the [principle of locality](#), and *as interpreted by quantum mechanics*, is considered evidence of quantum entanglement.

QGD explanation is simply that photons from path 1 are not reaching the mirror on the top right as it does in the earlier setup, hence electrons of the glass side of the half-silvered mirror are not excited from e_0^- to e_1^- as shown in figure 3 and 3a, so photons from path 2 are free to reach D1.

The examples discussed in this section are additional examples of experiments for which the outcomes support quantum entanglement, yet they can be explained classically.